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Forecasting Research Division
Technical Report No. 176

Second trial of increased vertical resolution in the global and limited area models

by

C A Wilson and O M Hammon

August 1995

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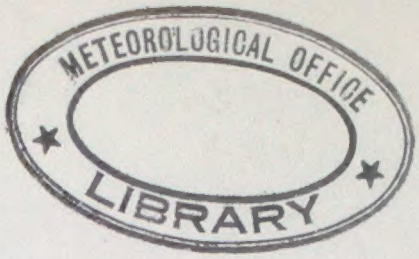

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SECOND TRIAL OF INCREASED VERTICAL RESOLUTION IN THE GLOBAL AND LIMITED AREA MODELS

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1. INTRODUCTION

This technical report contains the results of subjective and objective assessments of a a second test of extra vertical levels in the global and limited area forecast models compared to the standard 19 levels (**FIG 1.1, TABLE 1.1**) used operationally. A parallel suite trial was performed from 9 June-3 July 1995 with a new set of 30 levels. A previous trial (**Technical Report 114** ,Wilson and Hammon, 1995) of 31 levels based on the levels as used at ECMWF had shown the expected benefit of :

- generally smaller wind speed errors
- reduced upper tropospheric temperature errors

but also the following problems :

- too much low cloud, particularly over N Hemispheric land,
- which caused the cold bias to become worse
- the topmost levels needed to be reconsidered since there were larger interpolation errors
- the problems of the polar night stratosphere were exacerbated

With these in mind the new 30 level set were chosen to avoid problems both near the surface and at upper levels by keeping the bottom and top three levels the same as those used in the 19 level operational configuration. The extra levels were used to provide extra resolution in the free atmosphere of ~50hPa and increased resolution of ~25 hPa at jet levels compared to the current resolution there of ~50hPa.

The purpose of the trial was to see if the revised set of levels could provide improved forecasts of winds without the deficiencies noticed in the earlier trial. The model has undergone a large number of changes since July 1994, including the introduction of orographic roughness and a substantial revision of the gravity wave drag scheme which have resulted in reduced errors, especially during Northern hemisphere winter (**Technical Report 139** ,Milton et al, 1995) . A longer timestep for the physics has also been introduced (**Technical Report 112** ,Wilson and Hammon, 1995), code to prevent superadiabatic profiles (**Technical Report 125** ,Wilson et al, 1994) and modifications to the assimilation of observations of humidity by radiosondes (**Technical Report 132** ,Bell, 1994). A further aim of the trial was to see whether the beneficial impact on the limited area model noticed in

TABLE 1.1 UM 19 and 30 LEVELS (η)

19(UM)	30(UM)
.997	.997
.975	.975
.930	.930
.870	.880
	.827
.792	
----------	boundary layer top
	.775
	.725
.700	
	.675
	.625
.600	
	.575
	.525
.505	
	.475
.422	.430
	.390
.355	.355
	.327
.300	.302
	.277
.250	.252
	.227
.200	.202
	.177

19 (UM)	30(UM)
.150	.152
	.127
.099	.102
	.077
.056	.052
.0296	.0296
.0147	.0147
.0046	.0046

the earlier off-line trial (**Technical Report 113** ,Wilson and Hammon, 1995) was reproduced in a full trial coupled to the global model with increased resolution.

There were 2 complications in assessing the parallel trial. The first was due to an oversight in configuring the model to extra levels; the vertical diffusion which is applied to winds in the tropics was erroneously kept unchanged acting between model level numbers 8 and 14 (ie ~675-390 hPa) rather than specfied to act between levels 12 to 23 to parallel the operational range (~500-150 hPa), see **Table 1.1**. The second factor was the introduction of modified horizontal diffusion near steep orography which was implemented operationally on the 20 June (**Technical Report 165** ,Wilson,Hammon and Milton, 1995). Previous to this date the modification was only included in the 30 level trial configuration. Verification and subjective assessment will therefore concentrate on the period following the operational change.

The earlier trials with the limited area model suggested a seasonal dependence of the impact of increased resolution. The results from this trial also show a larger impact in the winter (southern hemisphere). A further test during the northern winter half year is planned to fully assess the potential benefits.

2. OBJECTIVE VERIFICATION

The analyses and forecasts were verified against observations (sondes and synops) for the period 09/06/95 to 03/07/95. Verification was also performed against analyses, each suite was verified against its own analyses for the same period. Time-mean results will mostly be discussed here . Results for forecast times T+0, T+24, T+48, T+72, T+120 and for areas "2", N. Hemisphere to 30N ("200"), Tropics 30N-30S ("300") and S. Hemisphere from 30S ("400") will be given.

The results of the first trial (**Technical Report 114** ,Wilson and Hammon, 1995) were somewhat contradictory in that positive benefit for forecast winds was shown by the verification against analyses but not by verification against sonde observations. To investigate this additional verification on model levels was performed during this trial using the assimilation files (acobs) and the assimilation code (see section 2.4).

As explained in the introduction the modified diffusion near steep orography was not included in the operational model until 20 June. Verification results have therefore been meaned separately for the periods before and after the change. ***Tables and figures below with suffixes a and b refer to the first and second periods respectively.*** Most attention should be given to the results from the second period when the test version and operational version are closer except for vertical resolution.

2. 1 RMS ERRORS -OVERALL SUMMARY

TABLES 2.1a,b summarise the objective scores for the N. Atlantic region (area 2) and extratropical N. Hemisphere. Each shows the percentage changes in rms errors for heights, temperatures , vector winds (8 levels each) , relative humidity (3 levels) and 3 surface fields.

%RMS CHANGE (TRIAL-OPERATIONAL) Period 09/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS

	T+0	T+24	T+48	T+72	T+120
AREA 2					
HEIGHTS					
850	2.7	-0.9	1.0	-2.8	-3.4
700	0.0	0.8	3.2	-1.8	-1.0
500	0.1	1.3	2.8	-1.1	1.3
300	-0.6	2.5	5.7	2.2	2.6
250	-2.2	1.6	6.6	4.2	3.2
200	-0.5	-0.3	5.9	5.8	5.1
100	-3.9	-4.1	2.0	6.3	6.7
50	4.5	0.7	5.4	10.6	12.2
MEAN	0.0	0.2	4.1	2.9	3.3
TEMPERATURES					
850	-5.6	2.1	9.2	8.0	8.2
700	-2.3	-3.6	-4.6	-4.4	2.0
500	-1.4	0.8	1.5	-1.6	2.8
300	-5.0	-2.6	-0.7	-2.5	0.3
250	-6.8	-4.5	-5.4	-3.2	-0.1
200	-7.2	-4.9	-4.4	-2.5	-3.0
100	-8.2	1.1	3.6	4.7	7.3
50	-9.1	-8.0	-5.4	-6.0	-4.8
MEAN	-5.7	-2.4	-0.8	-0.9	1.6
WINDS					
850	-1.0	0.5	0.3	-2.5	-2.1
700	-2.4	-0.6	-0.8	-2.3	-0.7
500	-1.0	-0.2	-1.3	-2.0	-0.4
400	-1.9	-0.3	-1.1	-1.3	-0.1
300	-0.9	-0.1	-1.3	-1.2	-0.8
250	-1.5	-0.1	-0.4	-1.0	-1.0
200	-3.9	-2.0	-1.3	-0.5	-1.8
100	-8.3	-2.2	-3.6	-6.5	-2.9
MEAN	-2.6	-0.6	-1.2	-2.2	-1.2
RH					
850	-2.2	6.7	9.2	7.0	9.4
700	0.2	-3.2	-2.4	-0.9	0.8
500	2.9	-1.6	-0.3	1.4	-2.6
MEAN	0.3	0.6	2.2	2.5	2.5
SURF					
PMSL	-0.8	3.9	1.6	-3.2	-4.5
TEMP	1.8	4.6	6.3	5.7	5.4
WIND	-0.4	-0.2	-1.1	-1.5	-1.7
MEAN	0.2	2.8	2.3	0.3	-0.3
MEANALI	-2.2	-0.4	1.0	0.2	1.2

	T+0	T+24	T+48	T+72	T+120
AREA N Hem to 30N					
HEIGHTS					
850	2.2	-3.0	-2.1	-3.2	-1.6
700	0.4	-0.9	1.1	-1.8	-0.1
500	0.5	1.2	2.9	-0.7	0.7
300	0.0	1.3	3.2	1.2	0.8
250	-1.2	-0.1	2.4	2.1	1.2
200	0.1	0.5	1.8	2.2	1.8
100	-1.7	-0.3	0.5	0.5	0.1
50	5.4	7.6	6.6	6.1	5.9
MEAN	0.7	0.8	2.0	0.8	1.1
TEMPERATURES					
850	-2.0	1.7	4.3	5.0	5.6
700	-1.6	-5.7	-3.7	-3.4	-2.3
500	-2.9	-3.6	-2.7	-1.8	0.0
300	-5.6	-3.5	-2.6	-2.3	-1.8
250	-6.5	-4.3	-3.4	-3.8	-0.4
200	-9.5	-4.9	-2.1	-1.2	-2.3
100	-9.8	-1.4	-3.9	-1.8	-1.6
50	-7.2	-8.0	-10.0	-10.7	-11.3
MEAN	-5.6	-3.7	-3.0	-2.5	-1.8
WINDS					
850	-0.5	0.3	-0.1	-1.3	-0.8
700	-2.3	-1.1	-1.4	-2.8	-0.8
500	-0.7	-1.2	-0.8	-2.2	-0.4
400	-2.1	-1.3	-2.5	-2.0	-0.1
300	-2.0	-2.7	-4.0	-3.0	-1.2
250	-2.6	-4.5	-4.3	-2.8	-1.8
200	-4.9	-7.5	-6.1	-3.1	-3.2
100	-10.9	-6.1	-7.8	-6.4	-5.7
MEAN	-3.3	-3.0	-3.4	-2.9	-1.7
RH					
850	-2.6	5.7	6.5	5.6	7.3
700	1.7	-1.0	-0.4	0.0	0.4
500	2.4	-1.1	-0.6	-0.6	-1.3
MEAN	0.5	1.2	1.8	1.7	2.1
SURF					
PMSL	-0.3	-0.4	-2.3	-3.3	-4.0
TEMP	3.2	5.5	6.9	6.3	5.6
WIND	-0.8	-0.8	-1.2	-1.4	-1.4
MEAN	0.7	1.4	1.1	0.5	0.1
MEANALI	-2.1	-1.3	-0.9	-1.0	-0.4

TABLE 2.1a

%RMS CHANGE (TRIAL-OPERATIONAL) Period 20/06/95-03/07/95
VERIFICATION AGAINST OBSERVATIONS

	T+0	T+24	T+48	T+72	T+120
AREA 2					
HEIGHTS					
850	3.6	-1.0	-2.2	-3.9	-2.9
700	0.3	-0.5	-2.2	-0.3	-2.1
500	-1.6	0.1	1.5	2.6	-0.8
300	-2.1	2.8	3.5	3.1	1.1
250	-4.2	1.8	4.0	3.4	1.6
200	-3.6	-0.4	2.6	3.9	1.3
100	-4.4	-6.1	-0.7	4.1	-1.1
50	1.5	-1.6	2.9	7.4	9.1
MEAN	-1.3	-0.6	1.2	2.5	0.8
TEMPERATURES					
850	-5.4	4.6	10.8	7.7	4.8
700	-3.2	-1.9	-1.1	-0.7	1.6
500	-0.9	-0.8	3.1	1.9	1.4
300	-4.9	1.2	-2.4	-1.7	6.6
250	-5.0	-3.5	-1.3	0.3	-0.5
200	-14.0	-7.7	-2.6	-3.5	2.3
100	-12.0	-5.0	-0.2	0.7	2.1
50	-7.9	-4.3	-6.6	-6.8	-4.6
MEAN	-6.7	-2.2	0.0	-0.3	1.7
WINDS					
850	-1.7	-0.1	0.3	0.0	-1.3
700	-2.2	-0.5	-1.4	-0.7	-1.4
500	-0.9	-0.6	0.0	0.6	-3.0
400	-1.1	0.4	1.0	3.1	-3.2
300	-0.2	0.4	0.1	1.4	-4.7
250	-1.8	0.6	0.0	1.1	-4.1
200	-2.6	1.6	2.6	1.9	-4.1
100	-5.4	-0.8	-0.8	-0.6	-5.0
MEAN	-2.0	0.1	0.2	0.8	-3.3
RH					
850	-4.3	4.3	6.2	6.2	6.7
700	-1.4	-0.7	-0.7	-1.2	2.5
500	5.0	-0.9	-1.9	-3.5	-1.7
MEAN	-0.2	0.9	1.2	0.5	2.5
SURF					
PMSL	0.6	-0.1	2.2	-0.4	-1.8
TEMP	0.6	2.5	2.7	3.1	7.0
WIND	-0.2	-0.4	-0.9	-0.2	-0.9
MEAN	0.3	0.7	1.3	0.8	1.4
MEANALI	-2.6	-0.6	0.6	1.0	0.2

	T+0	T+24	T+48	T+72	T+120
AREA N Hem to 30N					
HEIGHTS					
850	2.5	-1.1	-1.2	-0.3	-1.1
700	-0.7	0.6	-0.3	0.8	0.4
500	-0.7	0.3	0.5	1.8	0.5
300	-1.8	2.6	3.5	1.5	1.8
250	-2.1	2.9	3.8	1.8	2.5
200	-1.2	3.1	5.5	3.3	3.2
100	-2.6	-0.4	2.4	2.6	1.4
50	5.0	6.7	7.4	6.4	4.3
MEAN	-0.2	1.8	2.7	2.2	1.6
TEMPERATURES					
850	-0.5	3.9	5.9	5.8	3.9
700	-1.5	-2.6	-1.5	-1.7	-0.1
500	-2.5	-1.1	-0.1	-1.0	0.1
300	-4.1	1.4	0.6	-0.4	4.8
250	-6.0	-2.9	-0.4	-0.7	-0.4
200	-13.0	-5.9	-2.0	-2.1	-0.9
100	-15.0	-2.7	-1.4	0.0	-0.1
50	-8.1	-7.6	-10.9	-11.3	-11.0
MEAN	-6.3	-2.2	-1.2	-1.4	-0.5
WINDS					
850	-1.3	1.2	0.9	0.9	-0.8
700	-2.5	-0.7	-1.0	-0.7	-1.4
500	-0.9	-0.3	-0.4	0.0	-2.1
400	-0.7	0.3	0.7	1.4	-1.3
300	-1.2	-0.1	-0.7	-0.1	-2.4
250	-2.4	-0.5	-0.7	-0.1	-1.9
200	-3.4	-0.4	0.2	-1.0	-1.7
100	-8.9	-2.3	-0.2	1.0	-0.4
MEAN	-2.7	-0.4	-0.1	0.2	-1.5
RH					
850	-2.9	3.9	5.3	5.9	5.5
700	-0.2	-0.4	-0.8	-0.5	1.9
500	3.3	0.3	-0.5	-0.9	0.7
MEAN	0.1	1.3	1.3	1.5	2.7
SURF					
PMSL	1.5	-0.4	2.3	1.3	-0.2
TEMP	0.8	1.8	2.3	3.1	5.2
WIND	-0.1	0.0	-0.1	0.4	-0.7
MEAN	0.7	0.5	1.5	1.6	1.4
MEANALI	-2.4	0.0	0.6	0.6	0.3

TABLE 2.1b

A negative value shows the trial to be an improvement. Column and surface-means are also shown. **TABLES 2.2a,b** summarise the objective scores for the Tropics and extratropical S. Hemisphere. A quicker and clearer overall assessment is gained from the vertical profiles of the changes for all verification periods which are plotted in **FIGS 2.1,2.2,2.3 (a and b)** for height, temperature and vector wind errors respectively. A 1% threshold is shown dotted on these figures, beneath which the changes are regarded as not significant.

For all regions and both periods there is clearly an improvement at T+0 of the fit to observations for heights, temperatures and winds arising from the better vertical resolution. The largest improvements are for temperatures and winds at 100 hPa in the tropics and northern hemisphere where rms errors are better by 15% or more in some cases. Surface parameters are little different at T+0.

Errors in forecast heights are generally worse with 30 levels beyond T+0 except in the southern hemisphere up to 100 hPa. This is true for both verification periods **FIGS 2.1a,b** , (NB the change in scale for SHem in **FIG 2.1b**) . For the second period there are some beneficial improvements in area 2 balanced by some degradations; in the tropics the T+120 errors are smaller for levels up to 300 hPa although they are larger at T+48, T+72 (**FIG 2.1b**).

Temperature rms errors (**FIGS 2.2a,b**) are generally improved for all regions and at all forecast ranges. with the best improvements found at 200, 100 and 50 hPa. The exception is seen at 850 hPa where the errors are worse. This was found in the previous trial and is due to a general cooling of the lowest model levels (see section 2.4) and increased low cloud. However the increase in cloud cover is not as great as found in the first trial. Some of the improvement in the N hemisphere extratropics and tropical regions , particularly up to 250 hPa is reduced between the first and second periods; this is attributed to the lack of the modification to horizontal diffusion in the operational model during the first period (see **Technical Report 165**, Wilson et al, 1995). The southern hemisphere shows a generally consistent improvement at all verification levels.

Rms vector wind errors (**FIGS 2.3a,b**) are also generally better for the 30 level version. Some of the improvement shown in the first period is probably due to the modified horizontal diffusion (see **Technical Report 165**) especially at 250 and 200hPa. Again the reductions are largest and most consistent, averaging about 5% in the southern hemisphere. There may be some disadvantage to the trial version in the tropics due to the vertical diffusion being mistakenly applied to the middle rather than upper troposphere; when vertical diffusion was introduced operationally in March 1992 it reduced tropical upper wind errors and improved the Hadley cell (see **Technical Report 162**, Milton et al, 1995).

Overall the impact of extra vertical resolution is generally beneficial. There are some large reductions in rms errors at upper levels. The largest degradations are for heights, except for the winter (southern hemisphere). Taking changes greater than 1%, the number of scores from

%RMS CHANGE (TRIAL-OPERATIONAL) Period 09/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS

	T+0	T+24	T+48	T+72	T+120
AREA	Tropics 30N to 30S				
HEIGHTS					
850	-1.1	-7.7	-3.9	-3.3	-2.5
700	0.8	0.8	2.2	3.1	0.7
500	-0.1	1.1	1.1	3.9	-0.1
300	1.2	1.5	3.3	8.3	4.9
250	0.4	3.7	4.6	11.9	7.1
200	0.1	3.5	5.2	10.5	11.4
100	-3.8	-0.2	2.6	6.7	10.8
50	5.6	5.7	3.9	4.5	9.2
MEAN	0.4	1.0	2.4	5.7	5.2
TEMPERATURES					
850	-2.9	-5.5	-6.8	-4.7	-4.2
700	-3.3	-4.2	-4.6	-5.1	-7.0
500	0.6	-0.3	-4.8	-2.8	-7.7
300	-3.8	-0.6	-0.1	5.0	5.4
250	-2.2	-1.3	-1.8	2.2	5.9
200	0.4	1.3	5.2	9.0	9.3
100	-17.4	-5.9	-6.4	-5.3	-9.0
50	-15.9	-16.8	-19.5	-19.3	-20.8
MEAN	-5.6	-4.2	-4.8	-2.6	-3.5
WINDS					
850	-1.3	0.9	2.5	0.8	0.0
700	-3.1	-0.2	-0.2	-0.5	2.5
500	-1.2	-1.5	-1.0	-1.1	-1.5
400	-1.6	0.1	-0.8	-1.6	-2.3
300	-1.4	-2.4	-5.0	-1.8	-5.5
250	-2.2	-5.7	-6.9	-2.5	-5.5
200	-4.8	-10.4	-12.5	-3.5	-9.4
100	-13.1	-1.4	-1.4	0.4	0.3
MEAN	-3.6	-2.6	-3.2	-1.2	-2.7
RH					
850	-5.7	0.0	-1.5	-1.7	-3.7
700	-0.3	0.2	-1.3	-3.0	-4.1
500	7.0	-0.9	-2.7	-2.8	-4.5
MEAN	0.3	-0.2	-1.8	-2.5	-4.1
SURF					
PMSL	2.1	-5.1	-6.5	-6.8	-7.2
TEMP	-0.2	-0.8	-1.2	-1.6	-1.0
WIND	-1.9	-1.9	-1.8	-1.7	-1.1
MEAN	0.0	-2.6	-3.2	-3.4	-3.1
MEANALI	-2.3	-1.8	-2.0	-0.1	-1.0

	T+0	T+24	T+48	T+72	T+120
AREA	S Hem from 30S				
HEIGHTS					
850	-1.4	-1.8	-2.0	-0.8	0.5
700	2.5	0.7	-1.5	-1.9	3.1
500	2.8	1.2	-3.3	-4.0	-2.4
300	0.4	0.1	-2.3	-3.4	-4.2
250	-2.7	0.0	-1.7	-2.6	-4.6
200	-2.6	-1.2	-1.0	-3.5	-3.9
100	-2.2	3.3	3.4	1.6	4.4
50	3.0	-0.2	-1.7	-3.3	3.4
MEAN	0.0	0.3	-1.3	-2.2	-0.5
TEMPERATURES					
850	-3.5	3.1	4.4	-0.4	1.6
700	-7.8	-0.3	-3.2	-12.0	-4.6
500	4.2	-3.0	-2.4	-6.0	-5.7
300	-6.0	0.8	2.6	-0.4	4.0
250	-5.9	1.8	0.7	-4.9	-0.4
200	-5.4	-0.2	-2.6	1.9	-0.9
100	-16.6	2.2	-0.6	-3.3	-11.4
50	-6.4	-7.9	-5.9	-10.0	-4.8
MEAN	-5.9	-0.4	-0.9	-4.4	-2.8
WINDS					
850	-1.9	-2.1	-1.8	-4.8	1.6
700	-4.9	-0.7	-0.3	-3.3	-0.5
500	-2.1	3.0	1.2	-3.4	-3.5
400	-2.7	1.3	-0.7	-4.0	-0.3
300	0.9	1.8	1.0	-0.5	-1.0
250	-3.9	-1.5	0.1	-4.8	-1.6
200	-4.0	2.7	2.5	-3.5	-4.4
100	-11.7	1.2	0.3	-2.3	1.2
MEAN	-3.8	0.7	0.3	-3.3	-1.1
RH					
850	-5.7	0.8	2.3	5.8	2.8
700	-2.6	-1.5	-1.5	-2.2	4.2
500	9.2	0.3	1.2	-3.2	-6.0
MEAN	0.3	-0.1	0.7	0.1	0.3
SURF					
PMSL	1.0	-3.5	-2.5	-5.9	-7.2
TEMP	1.4	0.4	6.5	5.0	8.4
WIND	-0.4	-1.2	-1.9	-2.6	-3.2
MEAN	0.7	-1.4	0.7	-1.2	-0.7
MEANALI	-2.5	0.0	-0.4	-2.8	-1.2

TABLE 2.2a

%RMS CHANGE (TRIAL-OPERATIONAL) Period 20/06/95-03/07/95
VERIFICATION AGAINST OBSERVATIONS

	T+0	T+24	T+48	T+72	T+120
AREA	Tropics 30N to 30S				
HEIGHTS					
850	0.3	0.2	2.2	2.0	-5.5
700	1.2	2.0	3.8	3.5	-4.7
500	-0.8	0.9	2.6	1.0	-6.7
300	-0.4	2.8	6.0	4.7	-6.6
250	0.1	4.7	8.4	6.9	-1.6
200	-0.3	3.9	8.5	8.3	4.4
100	-4.7	-0.1	2.9	5.4	6.8
50	4.1	3.3	3.7	2.4	3.5
MEAN	-0.1	2.2	4.8	4.3	-1.3
TEMPERATURES					
850	-2.5	5.3	3.8	4.2	4.3
700	-2.5	-1.7	-3.2	1.3	-1.1
500	-1.1	-1.7	-4.0	-2.7	-9.7
300	-3.1	1.8	8.0	8.2	11.8
250	-3.1	-1.5	-1.3	0.8	9.2
200	-3.2	-2.4	3.1	4.8	3.5
100	-23.0	-9.3	-7.1	-8.0	-5.6
50	-18.2	-17.5	-19.4	-21.0	-21.2
MEAN	-7.1	-3.4	-2.5	-1.6	-1.1
WINDS					
850	-0.1	3.6	2.4	0.8	0.1
700	-3.6	-1.2	-0.5	0.9	0.7
500	-2.5	-0.1	-2.0	-0.4	-3.5
400	-2.2	1.5	-1.4	-0.4	-4.5
300	0.1	2.1	1.1	0.8	-2.7
250	-2.7	1.2	0.0	-0.2	-6.1
200	-3.5	0.0	1.2	0.9	-7.8
100	-16.5	-3.2	-0.8	-0.9	-0.9
MEAN	-3.9	0.5	0.0	0.2	-3.1
RH					
850	-4.8	3.6	0.5	2.4	1.8
700	0.4	-3.3	-3.1	-3.6	-5.2
500	4.4	-3.2	-3.4	-4.8	-4.5
MEAN	0.0	-1.0	-2.0	-2.0	-2.6
SURF					
PMSL	3.6	0.7	0.4	0.2	-4.5
TEMP	0.2	2.2	2.4	3.1	5.8
WIND	0.5	0.7	1.2	1.0	0.0
MEAN	1.4	1.2	1.3	1.4	0.4
MEANALI	-2.8	-0.2	0.5	0.7	-1.7

	T+0	T+24	T+48	T+72	T+120
AREA	S Hem from 30S				
HEIGHTS					
850	2.5	-1.8	4.6	1.2	-6.3
700	1.3	-1.6	3.9	2.7	-6.1
500	-1.4	0.0	2.9	1.5	-9.6
300	-3.1	-2.1	0.8	-3.1	-13.6
250	-5.9	-5.4	-1.1	-2.8	-13.3
200	-5.3	-5.9	-2.5	-4.3	-13.6
100	-9.6	-4.5	-2.5	-3.2	-0.4
50	1.5	-3.7	-2.7	0.0	10.8
MEAN	-2.5	-3.1	0.4	-1.0	-6.5
TEMPERATURES					
850	-3.6	0.1	-0.9	3.8	-2.7
700	1.9	3.1	3.7	0.6	-3.2
500	-2.3	-1.2	0.9	-4.9	-5.2
300	-6.6	-7.5	-7.0	-12.5	-17.3
250	-5.3	-1.1	2.0	-6.3	-12.0
200	-8.2	-2.1	2.1	-2.9	-5.0
100	-10.5	-6.2	-5.2	-0.4	-5.9
50	-7.6	-7.6	-10.5	-8.9	-8.7
MEAN	-5.3	-2.8	-1.9	-3.9	-7.5
WINDS					
850	-2.8	-2.4	-3.1	-3.0	-3.1
700	-4.0	-2.3	-5.7	-3.9	-2.6
500	-0.2	1.2	-3.6	-6.3	-2.3
400	-6.5	-3.3	-5.1	-7.3	-5.2
300	-3.9	-1.9	-3.5	-4.0	-7.9
250	-3.3	-0.9	-2.7	-3.3	-4.4
200	-4.5	-0.8	-1.7	-3.2	-7.1
100	-9.7	-1.5	-0.1	-2.3	-3.7
MEAN	-4.4	-1.5	-3.2	-4.2	-4.5
RH					
850	-0.9	1.5	-4.4	-0.1	-7.1
700	-1.0	-5.3	-8.4	-6.4	1.4
500	1.8	-2.8	-0.5	-0.8	-3.0
MEAN	0.0	-2.2	-4.4	-2.4	-2.9
SURF					
PMSL	0.8	1.8	3.3	-2.4	-5.6
TEMP	0.7	1.4	3.3	3.1	-1.5
WIND	-0.9	0.1	1.1	0.0	-8.0
MEAN	0.2	1.1	2.6	0.2	-5.0
MEANALI	-3.2	-2.1	-1.4	-2.6	-5.7

TABLE 2.2b

TABLES **2.1a,b and 2.2a,b** for which the trial was better are given in TABLES **2.3a,b**. For changes less than 1% operational and trial were deemed equal. For both periods assessed the trial has ahigher count. For the second period there is a more even spread between the trial and operational in all areas except the Southern Hemisphere where the trial is clearly better, although overall for all areas the trial is still favoured . In the previous trial (see **Technical Report 114**) large improvements were counteracted by some equally great degradations. This is not the case for this trial despite the worsened height errors compared to operational. Also the problem of increased cooling in the lower atmosphere has been found to be smaller than in the first trial, despite being run again in northern summer . There appears to be a signal from the southern hemisphere results that the impact is greater in the winter hemisphere. A further trial in northern winter is required to test this hypothesis. There is little improvement to surface pressure errors generally except for the southern hemisphere.

TABLE **2.3a** : Summary of objective verification scores from verification against observations (TABLES **2.1a and 2.2a**) Period 09/06-24/06/95

Area	Trial better	equal	operational better
N Atlantic ("2")	63	40	47
N Hemisphere	81	36	33
Tropics	81	31	38
S Hemisphere	79	33	38

TOTAL SCORE FOR EACH AREA=150

TABLE **2.3b** : Summary of objective verification scores from verification against observations (TABLES **2.1ba and 2.2b**) Period 20/06-03/07/95

Area	Trial better	equal	operational better
N Atlantic ("2")	56	46	48
N Hemisphere	42	65	43
Tropics	57	38	55
S Hemisphere	101	23	26

TOTAL SCORE FOR EACH AREA=150

VERIFICATION AGAINST ANALYSES

TABLES **2.4a,b and 2.5a,b** summarise the percentage changes in rms errors for verification against analyses. NB each version is verified against its own analyses. Vertical profiles of the changes for all forecast periods are plotted in FIGS **2.4a,b ,2.5a,b ,2.6a,b** for height,temperature and vector wind errors respectively. The clearest reductions in rms are

RMSE %CHANGE (TRIAL-OPERATIONAL)

VERIFICATION AGAINST ANALYSES PERIOD=09/06/95-24/06/95

	T+24	T+72	T+120
AREA 2			
HEIGHT			
850	1.8	-2.4	-0.4
700	1.7	-1.3	0.2
500	2.2	-0.8	1.1
300	2.4	0.2	1.5
250	3.2	1.1	1.4
200	3.4	2.1	2.5
100	4.7	3.0	8.2
50	-3.7	-6.0	5.9
mean	2.0	-0.5	2.6
TEMP			
850	13.3	11.3	10.8
700	3.3	-2.1	2.0
500	1.1	-5.1	2.9
300	-2.3	-6.2	-4.4
250	-3.6	-2.2	0.8
200	-0.8	-3.4	-5.0
100	8.6	3.3	4.1
50	-2.8	-3.6	-9.5
mean	2.1	-1.0	0.2
WIND			
850	1.6	-2.7	-0.6
700	1.6	-2.9	-1.7
500	-0.6	-3.6	-2.0
400	0.5	-2.3	-1.0
300	-2.1	-1.7	-1.9
250	-2.1	-2.5	-2.8
200	-2.1	-2.4	-2.2
100	1.9	-2.2	-4.4
mean	-0.2	-2.5	-2.1
RELHUM			
950	5.1	1.4	0.1
850	13.1	9.9	9.3
700	-2.6	-2.3	-1.6
500	-1.7	-3.9	-1.4
mean	3.5	1.3	1.6
PMSL	3.5	-2.4	1.6

	T+24	T+72	T+120
N.HEM			
HEIGHT			
850	-2.6	-7.7	-3.8
700	0.0	-6.3	-3.0
500	0.8	-5.8	-2.1
300	1.0	-4.9	-1.2
250	1.4	-3.8	-0.3
200	1.0	-2.7	1.3
100	5.7	0.9	6.1
50	-2.5	-0.8	6.6
mean	0.6	-3.9	0.5
TEMP			
850	5.2	6.2	6.1
700	-3.2	-4.8	-3.2
500	-1.2	-7.0	-2.5
300	-0.8	-3.6	-2.4
250	-3.0	-4.0	-1.2
200	-0.8	-4.2	-2.9
100	-1.4	-5.6	-1.4
50	0.0	-2.2	-5.2
mean	-0.7	-3.2	-1.6
WIND			
850	1.3	-6.5	-4.3
700	1.0	-5.5	-3.6
500	-1.2	-5.8	-2.6
400	-0.1	-5.6	-2.0
300	-2.4	-6.0	-2.6
250	-2.8	-5.1	-2.4
200	-4.3	-4.9	-2.9
100	1.6	-4.3	-5.8
mean	-0.9	-5.5	-3.3
RELHUM			
950	3.6	2.3	1.6
850	11.2	6.8	7.4
700	-1.1	-2.9	-2.3
500	-1.6	-3.7	-2.0
mean	3.0	0.6	1.2
PMSL	-3.8	-8.6	-4.5

TABLE 2.4a

RMSE %CHANGE (TRIAL-OPERATIONAL)

VERIFICATION AGAINST ANALYSES PERIOD=21/06/95-03/07/95

AREA 2	T+24	T+72	T+120	N.HEM	T+24	T+72	T+120
HEIGHT				HEIGHT			
850	0.0	-1.0	0.0	850	0.9	1.5	1.9
700	0.0	-0.6	1.1	700	0.9	0.7	2.1
500	0.7	0.2	1.6	500	0.8	0.5	1.5
300	2.8	0.1	0.8	300	3.1	0.9	1.0
250	2.7	1.2	1.4	250	4.4	2.2	1.6
200	3.0	3.5	2.5	200	5.7	4.9	2.1
100	0.0	13.4	10.8	100	5.6	11.6	7.0
50	-8.2	9.7	11.7	50	-3.7	4.4	7.9
mean	0.1	3.3	3.7	mean	2.2	3.3	3.1
TEMP				TEMP			
850	13.2	8.4	7.6	850	7.1	7.6	8.0
700	4.5	1.0	0.3	700	2.2	0.5	0.3
500	4.3	1.3	1.2	500	2.4	0.5	0.7
300	-1.7	-2.6	-1.3	300	0.0	0.0	0.7
250	-3.2	0.8	1.4	250	-1.6	1.2	2.1
200	0.0	-2.0	0.4	200	2.5	0.7	1.2
100	1.7	0.0	-1.5	100	1.5	-0.7	-4.6
50	0.0	-2.7	-2.0	50	0.0	1.4	-1.5
mean	2.4	0.5	0.8	mean	1.8	1.4	0.9
WIND				WIND			
850	2.9	-0.3	-0.6	850	2.5	1.4	0.6
700	2.4	-1.3	0.7	700	2.4	1.3	1.3
500	0.2	-1.1	0.5	500	0.5	-0.1	0.2
400	1.1	0.0	0.2	400	1.1	0.3	0.0
300	-0.5	-1.8	-1.4	300	-0.4	-1.2	-1.3
250	0.0	-1.7	-1.4	250	-0.1	-0.8	-1.3
200	2.0	-0.6	-1.3	200	0.5	-1.3	-2.1
100	2.8	-0.6	-2.0	100	4.9	1.1	-5.9
mean	1.4	-0.9	-0.7	mean	1.4	0.1	-1.1
RELHUM				RELHUM			
950	4.5	2.5	0.9	950	2.0	2.7	1.7
850	13.1	11.3	10.2	850	10.2	10.5	9.9
700	0.2	-1.7	0.8	700	1.1	0.7	1.0
500	-3.4	-3.0	-2.0	500	-1.4	-1.4	-1.7
mean	3.6	2.3	2.5	mean	3.0	3.1	2.7
PMSL	0.7	-0.5	0.4	PMSL	0.6	1.7	2.0

TABLE 2.4b

RMSE %CHANGE (TRIAL-OPERATIONAL)

VERIFICATION AGAINST ANALYSES PERIOD=09/06/95-24/06/95

	T+24	T+72	T+120		T+24	T+72	T+120
TROPICS				S.HEM			
HEIGHT				HEIGHT			
850	-2.5	-5.0	-7.6	850	-4.3	-10.2	-5.3
700	4.2	-0.8	-7.3	700	-3.1	-10.1	-5.9
500	4.1	4.3	-2.4	500	-1.3	-12.1	-6.9
300	3.2	6.7	5.1	300	0.6	-12.2	-7.5
250	3.6	8.2	9.8	250	1.6	-11.7	-7.7
200	7.0	11.8	15.3	200	2.2	-11.7	-9.8
100	11.3	15.3	21.0	100	6.7	-9.0	-7.6
50	2.9	14.6	22.5	50	2.8	-11.0	-10.0
mean	4.2	6.9	7.1	mean	0.7	-11.0	-7.6
TEMP				TEMP			
850	5.5	7.1	8.1	850	5.1	-1.3	-5.2
700	-8.5	-12.0	-14.3	700	0.0	-11.6	-7.4
500	-3.4	-13.0	-13.8	500	0.0	-11.7	-7.4
300	0.0	0.8	8.5	300	3.4	-3.9	-4.7
250	1.3	7.3	15.6	250	4.6	-3.5	1.4
200	2.5	6.4	10.2	200	12.0	-2.9	1.9
100	35.4	29.1	19.6	100	11.2	-4.1	-6.6
50	4.1	-1.8	-0.7	50	5.2	-1.3	-4.1
mean	4.6	3.0	4.2	mean	5.2	-5.0	-4.0
WIND				WIND			
850	4.3	-1.5	-2.1	850	-0.9	-5.7	-1.5
700	5.6	-2.4	-1.9	700	-0.3	-5.8	-2.6
500	-1.8	-4.8	-6.7	500	0.2	-7.5	-3.9
400	5.0	0.2	-4.1	400	2.0	-7.2	-3.7
300	8.0	2.9	-0.6	300	-0.5	-8.6	-6.1
250	3.4	2.0	0.8	250	0.3	-7.6	-5.7
200	4.9	3.3	1.3	200	2.0	-8.7	-6.9
100	19.7	8.5	-1.7	100	8.0	-5.8	-7.1
mean	6.1	1.0	-1.9	mean	1.4	-7.1	-4.7
RELHUM				RELHUM			
950	-2.1	-5.6	-8.4	950	0.1	-2.0	-6.1
850	15.2	11.4	6.4	850	14.9	8.6	7.9
700	-0.6	-5.3	-7.0	700	2.7	-2.2	0.6
500	-5.6	-10.9	-11.1	500	-1.3	-5.3	-4.0
mean	1.7	-2.6	-5.0	mean	4.1	-0.2	-0.4
PMSL	-8.3	-11.0	-8.5	PMSL	-4.4	-10.5	-5.5

TABLE 2.5a

RMSE %CHANGE (TRIAL-OPERATIONAL)

VERIFICATION AGAINST ANALYSES PERIOD=21/06/95-03/07/95

	T+24	T+72	T+120		T+24	T+72	T+120
AREA	2			S.HEM			
HEIGHT				HEIGHT			
850	0.0	-0.9	-3.9	850	-1.4	0.4	0.5
700	0.0	0.9	-4.3	700	-0.5	1.3	0.8
500	0.7	0.7	-3.6	500	0.4	1.2	-0.9
300	2.8	9.0	5.7	300	-0.9	1.0	-1.6
250	2.7	11.6	10.9	250	-1.2	1.9	-1.0
200	3.0	14.9	16.1	200	-0.3	1.7	-0.7
100	0.0	21.0	23.9	100	2.1	3.6	3.7
50	-8.2	20.7	26.5	50	-2.6	1.7	4.2
mean	0.1	9.7	8.9	mean	-0.6	1.6	0.6
TEMP				TEMP			
850	13.2	10.9	9.4	850	1.9	4.2	1.2
700	4.5	-5.9	-8.3	700	-0.6	-2.7	-4.2
500	4.3	-12.8	-12.8	500	0.7	-0.3	-2.0
300	-1.7	5.7	9.4	300	4.1	2.0	-0.6
250	-3.2	5.9	14.7	250	5.8	0.7	-0.8
200	0.0	3.5	2.2	200	13.1	6.6	1.8
100	1.7	28.6	21.3	100	3.5	4.3	-2.5
50	0.0	6.7	3.6	50	4.9	1.4	-0.5
mean	2.4	5.3	4.9	mean	4.2	2.0	-1.0
WIND				WIND			
850	2.9	3.3	1.4	850	1.4	0.4	-0.5
700	2.4	2.9	1.7	700	0.7	-0.2	-0.7
500	0.2	-4.6	-6.8	500	0.7	-1.3	-2.2
400	1.1	1.4	-1.8	400	2.4	0.6	-1.5
300	-0.5	6.0	0.4	300	-0.5	-1.1	-2.8
250	0.0	8.4	3.2	250	0.9	-0.1	-2.3
200	2.0	11.9	6.4	200	1.6	-0.4	-3.5
100	2.8	10.1	2.7	100	6.3	4.3	-0.1
mean	1.4	4.9	0.9	mean	1.7	0.3	-1.7
RELHUM				RELHUM			
950	4.5	2.0	0.0	950	-0.7	-3.7	-2.1
850	13.1	13.8	9.0	850	15.0	7.3	6.9
700	0.2	-0.9	-1.7	700	3.5	0.3	0.5
500	-3.4	-9.1	-6.5	500	-1.6	-3.4	-5.1
mean	3.6	1.5	0.2	mean	4.1	0.1	0.1
PMSL	0.7	-1.3	-3.4	PMSL	-2.2	-0.3	0.7

TABLE 2.5b

for vector wind errors, especially at T+72, for area 2 and N Hemisphere and S Hemisphere. for the period before the modified diffusion was made operational (**FIG 2.6a**) . For the second period (**FIG 2.6b**) many of the improvements are no longer evident however. As noted for the verification aginst observations some of the improvement during the first period is due to the modified diffusion. Another factor may be the better analyses with 30 levels, which makes the forecast errors appear worse since each suite version is verified against its own analyses. However the contrast with the generally more favourable improvements shown by the verification against sondes is somewhat puzzling, especially for the Southern hemisphere (see **FIG 2.3b**).

As for verification against radiosondes the errors in forecast heights are generally worse with 30 levels (**FIG 2.4a,b**) with the largest degradations above 300hPa in the tropics. Again some of the benefits from the first period are absent from the second mean period, and the improvements in the southern hemisphere found for verification against observations is less evident, especially at T+120.

For the N. Atlantic , extratropical N. Hemisphere and tropics bigger temperature errors at 850hPa are shown(**FIG 2.5a,b**), as for the verification against sondes (**FIG 2.2a,b**). By contrast the rms errors at 100hPa are worse for the trial, again no doubt affected by the improvement in the analyses used for verification.

TABLES 2.6a,b summarise the overall performance of the trial based on the scores in **TABLES 2.4a,b , and 2.5a,b**. Each shows the number of scores for which the rms changed by greater than 1% to decide whether the trial or operational were better in each area,with changes less than 1% deemed equal. The trial version is favoured in all regions except the tropics for the first period (**TABLE 2.6a**), but is less favoured for the second period (**TABLE 2.6b**). In comparison with the verification against observations (**TABLE 2.3b**) there is not so much evidence of improved performance from the 30 level version; the lack of consistency is most apparent for the southern hemisphere. Other objective assessments have been made using the observation processing database (OPD) and assimilation files to seek collaborating evidence, eg verification against aircraft reports see below.

TABLE 2.6a : Summary of objective verification scores from verification against analyses (TABLES **2.4a and 2.5a**) Period 09/06-24/06/95

Area	Trial better	equal	operational better
N Atlantic ("2")	40	11	36
N Hemisphere	59	12	16
Tropics	32	8	47
S Hemisphere	58	10	19

TOTAL SCORE FOR EACH AREA=87

TABLE 2.6b : Summary of objective verification scores from verification against analyses (TABLES **2.4b and 2.5b**) Period 21/06-03/07/95

Area	Trial better	equal	operational better
N Atlantic ("2")	21	34	32
N Hemisphere	13	30	44
Tropics	20	9	58
S Hemisphere	21	35	31

TOTAL SCORE FOR EACH AREA=87

2.2 BIASES AND VERTICAL DISTRIBUTION OF ERROR

The verifications against surface observations and sondes will mostly be shown unless the pattern from verification against analyses is very different. Also we will concentrate on results for the second verification period.

PMSL

FIGURE **2.2.1** shows the bias and rms errors (in hPa) ,verified against observations, from T+0 to T+120 for mean sea-level pressure for N Atlantic , N Hemisphere, Tropics and S. Hemisphere. The positive biases in the N. Hemisphere areas are generally slightly greater whilst in the tropics there is a beneficial reduction in negative bias. Small improvements in rms at T+72 and T+120 are found in the tropics and southern hemisphere. Overall most of the changes are probably not significant.

HEIGHT

FIGURE **2.2.2** shows the bias (left) and rms (right) height error profiles for T+120 for area 2 (top) and N Hemisphere (bottom). FIGURE **2.2.3** shows the same for the tropics and S Hemisphere. It is quite apparent that there has been a worsening of the negative height bias,

particularly in extratropical regions, as was found in the previous enhanced vertical resolution trial (see **Technical report 114**), although the size of the changes is not quite so great for this trial, and the rms errors are less affected and even improved (for S Hemisphere and tropics up to 300 hPa).

TEMPERATURE

FIGURES 2.2.4, 2.2.5 show the bias (left) and rms (right) temperature error profiles at T+0 and T+120 for area 2 (top) and N Hemisphere (bottom). **FIGURES 2.2.6,2.2.7** shows the same for the tropics and S Hemisphere. The benefit of extra levels is clearly seen at T+0 by a better fit to sonde observations with smaller biases and rms errors. The improvements are greatest in the upper troposphere and stratosphere. Similar benefits were found with the ECMWF model when the resolution was increased from 19 to 31 levels (Simmons, 1993). By T+120 there is a larger cold bias than for the operational version at all levels up to 300hPa in the N Hemisphere extratropics, and 200hPa in the tropics leading to the worse height biases. The larger cold bias is first evident at the lowest 5 model levels within the boundary layer at T+24 (**FIGURE 2.16** , NB the bias is here plotted as OB- FC). At other levels at this time the extra resolution has generally improved the bias . The cold bias gets progressively worse with forecast length and gradually affects higher levels (eg T+72, **FIGURE 2.17**) .

WINDS

FIGURE 2.7 shows the bias (left) and rms vector (right) wind error profiles for T+0 for area N Hemisphere, tropics and S Hemisphere (bottom). Wind speeds are generally slightly better and the rms fit to observed sonde winds is better with extra resolution, as was found for temperature and agrees with the results found at ECMWF (Simmons, 1993) . By T+24 (**FIGURE 2.8**) the biases are still very similar. However the expected improvement in rms vector winds is not realised except for the S Hemisphere. Verification against analyses (not shown) gave similar results, with worse scores in the tropics; this may partly be due to the mistake in applying vertical diffusion (see **FIGURES 2.14, 2.15**). At longer forecast ranges, eg T+120 (**FIGURE 2.9**) there appears to be some improvement in rms vector wind errors from extra vertical levels.

Since radiosonde wind observations are mostly over land some further verification was examined to complement the standard verification figures. Some independent figures are available from the Observation Processing Database (OPD) for the background T+6 errors (see section 2.3), and for T+24 forecasts using the acobs file to compare with aircraft observations (see section 2.4).

2.3 OBSERVATION-BACKGROUND WIND ERRORS AGAINST AIREPS

The Observation Processing Database (OPD) from both trial and operational was used to look at background (T+6) errors against aireps. Only the second period following the operational chnage to include the modified horizontal diffusion will be discussed.Ranking the O-B differences by speed bands the operational loss of speed compared to aireps is reduced with extra vertical resolution (**FIGURE 2.11c, and TABLE 2.7**, global region); background rms vector wind errors are similar or improved, particularly for 60-80ms^{-1}s and in excess of 80ms^{-1}

Background errors (against aireps)
Jun21 - Jul 03 1995
400-101hPa

Operational				30 levels				
	MEAN O&B SPEED m/s	MEAN O-B SPEED m/s	RMS O-B VECTOR m/s	No. OBS	MEAN O-B SPEED m/s	RMS O-B VECTOR m/s	No. OBS	%mean diff	%rms diff
90S-30S									
Total no. Observations				1641	Total no. Observations		1642		
0-3	******	******		0	******	******	0		
3-20	-0.08	6.35		196	-0.18	6.26	196	125.0	-1.4
20-40	0.35	6.39		710	0.23	6.4	704	-34.3	0.2
40-60	1.52	7.55		443	1.47	7.61	452	-3.3	0.8
60-80	2.11	10.52		205	1.74	10.43	201	-17.5	-0.9
>80	4.06	10.89		87	3.25	10.41	89	-20.0	-4.4
ALL	1.03	7.61		1641	0.87	7.57	1642	-15.5	-0.5
30N-30S									
Total no. Observations				10050	Total no. Observations		10038		
0-3	-0.48	2.92		461	-0.59	2.98	447	22.9	2.1
3-20	0.81	5.02		7029	0.77	5.02	7060	-4.9	0.0
20-40	1.02	6.28		1691	0.99	6.49	1658	-2.9	3.3
40-60	0.94	7.27		603	0.78	7.72	601	-17.0	6.2
60-80	1.15	7.74		235	0.67	7.6	241	-41.7	-1.8
>80	1.88	7.63		31	1.48	7.43	31	-21.3	-2.6
ALL	0.8	5.42		10050	0.75	5.49	10038	-6.3	1.3
30N-90N									
Total no. Observations				32704	Total no. Observations		32702		
0-3	-1.09	3.4		289	-1.14	3.4	292	4.6	0.0
3-20	0.4	5.45		15745	0.36	5.42	15712	-10.0	-0.6
20-40	0.63	7.12		12072	0.57	7.09	12087	-9.5	-0.4
40-60	1.39	7.76		4132	1.26	7.75	4130	-9.4	-0.1
60-80	3.53	7.95		466	3.15	7.63	481	-10.8	-4.0
>80	******	******		0	******	******	0		
ALL	0.64	6.45		32704	0.58	6.42	32702	-9.4	-0.5
Global									
Total no. Observations				44395	Total no. Observations		44382		
0-3	-0.72	3.11		750	-0.81	3.15	739	12.5	1.3
3-20	0.52	5.33		22970	0.48	5.31	22968	-7.7	-0.4
20-40	0.66	7		14473	0.6	6.99	14449	-9.1	-0.1
40-60	1.35	7.68		5178	1.22	7.73	5183	-9.6	0.7
60-80	2.59	8.55		906	2.2	8.31	923	-15.1	-2.8
>80	3.49	10.13		118	2.79	9.73	120	-20.1	-3.9
ALL	0.69	6.28		44395	0.63	6.27	44382	-8.7	-0.2

TABLE 2.7

(FIGURE 2.11d). The results from individual latitude bands for the N. Hemisphere (FIGURE 2.10a,b),tropics (FIGURE 2.10c,d) and S. Hemisphere (FIGURE 2.11a,b) are broadly the same. The largest improvements are at higher wind speeds and for the winter(southern) hemisphere as expected. The bulk of the observations are for the North Atlantic and North Pacific (TABLE 2.7) and the results indicate a greater reduction of negative speed bias than was found from the comparison against radiosonde winds. The degree to which this improvement is retained into the forecasts has been assessed by verfiying against aircraft observations using the assimilation (acobs) files (next section).

2.4 VERIFICATION ON MODEL LEVELS AGAINST OBSERVATIONS USING ACOBS FILES

Additional verification on model levels was performed during this trial using the assimilation files (acobs) and the assimilation code . This was mainly aimed at wind verification against aireps in order to demonstrate directly any benefits for aviation wind forecasts. The results of the first trial (**Technical Report 114** ,Wilson and Hammon, 1995) were somewhat contradictory in that positive benefit for forecast winds was shown by the verification against analyses but not by verification against sonde observations.

Compared to aireps, the wind speed bias at model levels is generally smaller with extra levels (**FIG 2.12** NB the bias, on left,is here plotted as OB- FC, so positive values indicate forecast speeds too low). The rms vector winds are better above eta=.4 in the N Hemisphere, although the marked difference at eta=.177 looks suspect. The biggest improvements are again mostly in the S Hemipshere. The improvements with extra resolution are largely retained at T+72 (**FIG 2.13**). These results confirm the small but beneficial changes noted from the T+6 background differences. For completeness we also show the verfication on model levels against radiosonde winds (**FIGS 2.14, 2.15**). The differences are mostly smaller than for aircraft observations which sample higher winds speeds generally; the improvement in the Southern Hemisphere can again be seen at T+72.

The verification of temperatures (**FIGS 2.16, 2.17**) shows the cooling in the lowest layers already remarked on, as well as the biggest improvements above eta=0.15 for both bias and rms errors (cf **FIGS 2.2.5,2.2.7**).

2.5 LIMITED AREA MODEL VERIFICATION

The analyses and forecasts were verified against observations (Sondes and synops) for the period 14/06/95 to 03/07/95. (There were system problems in the parallel suite which prevented comparison of verification results over a longer period.) Verification was also performed against analyses, each suite was verified against its own analyses for the period 12/06/95 to 03/07/95 . Time-mean results will mostly be discussed here . Results for forecast times T+0, T+24 and for areas "5", "88" and for analyses "888" will be given. Area "5" is the near UK from Iceland to mid Spain, area "88" is 80W-40E, 30-80N and "888" is the full LAM area.

%RMS CHANGE (TRIAL-OPERATIONAL) PERIOD 14/06-21/6/95
VERIFICATION AGAINST OBSERVATIONS

		T+0	T+24	T+0	T+24
AREA		5		88	
HEIGHTS					
	850	3.3	-3.3	4.2	-1.3
	500	1.6	6.8	4.1	4.8
	300	-2.5	7.1	-0.2	8.7
	250	-2.2	7.8	-4.3	8.1
	200	-2.4	9.0	-0.8	7.9
	100	10.5	18.7	1.8	5.6
MEAN		2.8	15.4	1.6	11.3
TEMPERATURES					
	850	-11.9	5.7	-11.8	5.6
	500	-1.8	-4.7	-2.1	-1.3
	300	-9.1	-3.9	-6.9	-2.2
	250	0.7	7.7	-1.2	-0.8
	200	3.7	-0.6	-0.5	-0.7
	100	-4.1	5.8	-7.9	0.0
MEAN		-3.7	1.7	-5.1	0.1
WINDS					
	850	-2.1	1.0	-2.2	0.5
	500	1.2	-0.9	0.0	-0.8
	300	1.1	-1.2	1.0	-1.4
	250	-1.9	-3.4	-1.6	-2.3
	200	-3.7	0.2	-2.8	1.1
	100	0.2	-0.1	-11.4	-0.4
MEAN		-0.9	-0.7	-2.8	-0.5
RH					
	850	-10.1	4.4	-11.1	7.2
	700	2.7	-9.0	5.6	-6.4
	500	0.4	-3.4	7.0	-1.6
MEAN		-2.3	-2.7	0.5	-0.3
SURF					
PMSL		7.9	3.4	9.6	6.3
TEMP		-0.9	0.0	5.1	8.4
WIND		-0.3	-1.6	-0.3	-0.2
MEAN		2.2	0.6	4.8	4.8
MEANALL		-0.8	1.9	-1.1	1.9

TABLE 2.8a

%RMS CHANGE (TRIAL-OPERATIONAL) PERIOD 20/06-03/07/95
VERIFICATION AGAINST OBSERVATIONS

		T+0	T+24	T+0	T+24
AREA		5		88	
HEIGHTS					
	850	-3.4	-3.3	0.7	-4.2
	500	-2.2	0.8	-1.9	-0.5
	300	-0.3	8.7	-1.9	5.4
	250	-5.7	4.8	-2.8	4.4
	200	-2.6	3.1	-2.8	3.7
	100	-1.8	-0.4	-4.7	-2.9
MEAN		-5.3	4.6	-4.5	2.0
TEMPERATURES					
	850	-4.4	5.7	-4.6	7.1
	500	-5.7	-0.3	-3.1	-0.4
	300	-2.9	-4.0	-4.6	-1.0
	250	-9.8	-4.6	-6.0	-7.8
	200	-15.9	-1.1	-14.0	-6.3
	100	-10.0	-6.1	-20.4	-3.3
MEAN		-8.1	-1.7	-8.8	-1.9
WINDS					
	850	-3.3	-1.6	-2.7	-1.1
	500	-2.3	-0.9	-1.2	-1.5
	300	0.6	2.0	-0.9	0.8
	250	0.5	3.1	-1.5	0.8
	200	-6.6	0.5	-5.8	-0.2
	100	-10.1	-2.5	-20.1	-1.2
MEAN		-3.5	0.1	-5.4	-0.4
RH					
	850	-13.5	6.3	-10.9	7.0
	700	-5.8	-2.9	-1.7	-3.0
	500	4.2	-4.2	7.1	-3.4
MEAN		-5.0	-0.3	-1.8	0.2
SURF					
PMSL		0.0	-1.7	1.5	-0.1
TEMP		1.0	4.7	2.4	4.7
WIND		-0.1	-1.0	0.0	0.0
MEAN		0.3	0.7	1.3	1.5
MEANALL		-4.2	0.2	-4.2	-0.1

TABLE 2.8b

2.5 RMS ERRORS -OVERALL SUMMARY FOR LAM

Only a brief summary of the main results will be given since most of the major impacts have already been described for the global model in section 2.1. Verification results have been meaned separately for the periods before and after 20 June when the operational change was made to modify horizontal diffusion near steep orography . ***Tables and figures below with suffixes a and b refer to the first and second periods respectively.***

TABLES 2.8a,b summarise the objective scores for verification against observations. Each shows the percentage changes in rms errors for heights, temperatures and winds (6 levels each) and relative humidity (3 levels) and 3 surface fields. A negative value shows the trial to be an improvement. Column and surface-means are also shown. The most noticeable impact of increased resolution is reduced errors at T+0, especially for upper level temperatures and winds, as was found for the global results. Other features such as worse 850 hPa temperature errors and worse heights at T+24 are also apparent. The better fit at T+0 is more pronounced for the second period (**TABLES 2.8b**).

TABLES 2.9a,b summarise the overall performance of the trial based on the scores in **TABLES 2.8a,b** Each shows the number of scores for which the rms changed by greater than 1% to decide whether the trial or operational were better in each area. For changes less than 1% operational and trial were deemed equal. With 24 fields and 2 verification times there are 48 possible scores in total for each area.

The overall impression is the trial outperforms the operational version. Much of the improvement comes from the better T+0 fields.

TABLE 2.9a : Summary of objective verification scores from **TABLE 2.8a** Period 14/06-21/06/95

Area	Trial better	equal	operational better
5	19	11	18
88	18	13	17

TOTAL SCORE FOR EACH AREA=48

TABLE **2.9b** : Summary of objective verification scores from TABLE **2.8b** Period 20/06-03/07/95

Area	Trial better	equal	operational better
5	27	12	9
88	28	11	9

TOTAL SCORE FOR EACH AREA=48

TABLES **2.10a,b** summarise the objective scores for verification against analyses at T+24. The results disagree somewhat with those from verification against observations. The improvement to winds at T+24 is generally greater, except at 850 hPa and at 100hPa where the improved analyses lead to an apparent worsening. The results for the second period are also generally less favourable to the trial, whereas the reverse was found for the verification against observations.

The overall summary is shown in TABLES **2.11a,b**. which show that although the trial was better during the first period when the horizontal diffusion change was not included operationally , the trial was worse than the operational version during the second period 21/06-03/07/95.

TABLE **2.11a** : Summary of objective verification scores from TABLE **2.10a** Period 12/06-21/06/95

Area	Trial better	equal	operational better
5	14	0	9
88	10	4	9
888	8	6	9

TOTAL SCORE FOR EACH AREA=23

TABLE **2.11b** : Summary of objective verification scores from TABLE **2.10b** Period 21/06-03/07/95

Area	Trial better	equal	operational better
5	5	4	14
88	7	5	11
888	7	6	10

TOTAL SCORE FOR EACH AREA=23

2.6 OBJECTIVE VERIFICATION - SUMMARY

The verification scores have shown some of the expected benefits from extra vertical resolution. Whilst overall the rms errors are comparable to the operational errors the trial is

RMSE %CHANGE (TRIAL-OPERATIONAL) PERIOD 0Z,12/6 - 0Z,20/6/95
VERIFICATION AGAINST ANALYSES

	T+24	T+24	T+24
AREA	5	88	888
HEIGHTS			
850	-4.0	-5.2	-1.0
500	-4.8	-5.8	-3.3
300	-2.7	-1.1	0.0
250	-2.6	2.1	3.2
200	1.1	5.9	7.0
100	14.5	14.0	15.5
MEAN	0.3	1.6	3.6
TEMPERATURES			
850	35.5	20.0	12.7
500	-4.8	-1.2	-2.4
300	-8.8	-2.4	-1.7
250	-2.7	0.0	-0.7
200	-4.9	-0.8	-0.8
100	11.5	8.7	11.6
MEAN	4.3	4.0	3.1
WINDS			
850	5.3	3.8	3.1
500	-4.1	-2.8	-3.4
300	-5.7	-5.4	-4.7
250	-9.0	-6.9	-6.2
200	-4.5	-1.2	-1.3
100	1.5	7.0	8.8
MEAN	-2.8	-0.9	-0.6
RH			
950	2.0	7.8	6.5
850	24.3	19.6	16.7
700	-3.5	-0.8	0.1
500	-2.8	-3.3	-3.5
MEAN	5.0	5.8	4.9
PMSL	1.5	-0.8	0.0
MEANALL	1.4	2.2	2.4

TABLE 2.10a

RMSE %CHANGE (TRIAL-OPERATIONAL) PERIOD 0Z,21/06 - 0Z,03/07/95
VERIFICATION AGAINST ANALYSES

	T+24	T+24	T+24
AREA	5	88	888
HEIGHTS			
850	2.1	-0.9	0.0
500	1.7	-0.7	-0.8
300	5.2	1.0	0.5
250	8.2	2.0	2.6
200	12.3	4.8	6.6
100	13.3	14.4	15.3
MEAN	7.1	3.4	4.0
TEMPERATURES			
850	22.1	13.3	10.2
500	1.3	-1.1	-1.1
300	-3.7	-2.5	-1.7
250	-3.9	-2.2	-1.5
200	-2.3	-0.8	0.0
100	14.3	4.5	9.2
MEAN	4.6	1.9	2.5
WINDS			
850	3.4	4.4	3.3
500	-1.0	-1.2	-1.9
300	-2.8	-3.9	-3.8
250	0.3	-2.5	-2.1
200	7.1	1.9	2.2
100	0.7	10.7	12.5
MEAN	1.3	1.6	1.7
RH			
950	1.2	3.0	2.9
850	18.7	13.7	11.3
700	0.9	-0.3	-0.1
500	-3.5	-4.5	-3.0
MEAN	4.3	3.0	2.8
PMSL	4.4	2.7	0.7
MEANALL	4.3	2.4	2.7

TABLE 2.10b

more often favoured. Verification against aireps shows the forecast winds to be better, particularly at upper flight levels. However against sondes these improvements are less obvious. As with the first trial there is increased low level cooling which lead to worse height errors at later forecast ranges, but the problem is not so great as in the first trial. The cause of the cooling is increased low cloud amount, especially over N Hemisphere land (see **FIGURE 3.4**, below). The greatest improvements were found in the (winter) southern hemisphere.

3. SUBJECTIVE ASSESSMENT - GLOBAL MODEL

Daily comparison of trial and operational charts during the parallel suite trial showed few big differences in the Northern Hemisphere summer, and the main impact was seen in the differences developing in mean sea level pressure and 500hPa in the Southern Hemisphere winter at T+72 onwards. This report will concentrate on the subjective assessment of forecasts run during the period 21/06/95 to 03/07/95, since this latter period of the trial provided a cleaner test of the impact of the increased vertical resolution.

A. NORTHERN HEMISPHERE.

Most differences were due to small positional, depth and pattern differences rather than due to evolution changes. Differences between the mean sea level pressure and 500hPa forecasts of > 8hPa and > 6dm were assessed and the results at T+120 are summarised in **Tables 3.1 and 3.2** below.

TABLE 3.1. Subjective assessment of mean sea level pressure differences at T+120 - Northern Hemisphere. (Overall; Trial better 5, Equal 12, Oper better on 5 occasions.)

Differences	Nr.	Trial better	equal	Oper better
Pattern -strength, direction of flow	7	2	3	2
Depth - depressions,troughs	3	0	1	2
Positional	6	1	4	1
Evolution	3	1	2	0
Pressure values	3	1	2	0

TABLE 3.2 Subjective assessment of 500hPa height differences at T+120 - Northern Hemisphere. (Overall; Trial better 9, Equal 4, Oper better on 5 occasions.)

Differences	Nr.	Trial better	equal	Oper better
Pattern -strength, direction of flow	9	5	2	2
Depth - cold pools,troughs	1	0	0	1
Positional	6	4	1	1
Evolution	1	0	1	0
Height values	1	0	0	1

These two tables show that overall the assessment at T+120 was neutral for mean sea level pressure differences and slightly in favour of the trial for 500hPa height differences.

The largest difference between north Pacific depressions at T+120 is shown in FIGURE 3.1. The verifying analysis for 12Z 24/06/95, FIGURE 3.1d, features two Pacific depressions; the first, depth 1009hPa, in the Gulf of Alaska, and the second, depth 1006hPa, further south at 40N 155W. Neither forecast succeeded in resolving both centres accurately. However, the operational forecast, FIGURE 3.1b, predicted the northern depression more accurately, whilst the trial forecast, FIGURE 3.1a, predicted, a main centre midway between the two depressions.

The 500hPa analysis for 12Z 29/06/95, FIGURE 3.2d, shows a deep cold pool of 538dm in the North Atlantic close to New Foundland. The dipole indicated in the difference chart, FIGURE 3.2c, gives an example of a typical positional difference in the T+120 forecasts of the cold pool verifying at this time. In this case, the trial forecast low, FIGURE 3.2a, is slightly further south and closer to the analysed position.

FIGURE 3.3 compares the T+24 trial and operational 250hPa jets in the Northern Hemisphere. The impact in the North Atlantic was small but there was a more noticeable impact on the subtropical jet, 30-40N, mainly 30E-120E over land, with the trial jets, FIGURE 3.3a, being on average 1-3 ms^{-1} stronger.

Each trial forecast showed an increase in low cloud plus a smaller decrease in upper cloud. The mean low,medium and high cloud fractions for the trial and operational forecasts in the Northern Hemisphere (north of 30N) and for Area 2 are compared in Table 3.3 below. The increase in low cloud in the Northern Hemispere, FIGURE 3.4, is small , fractions 0.1-0.3, and can be seen mainly over land. A comparison of cloud cross sections, FIGURE 3.16, indicates that the largest increase is at 850hPa.

TABLE 3.3. Comparison of mean forecast layer cloud fractions in the Northern Hemisphere.

Cloud N. Hem. (30N-90N)	T+24 30 levels / oper	T+72 30 levels / oper	T+120 30 levels / oper
low	0.36 / 0.32	0.40 / 0.34	0.41 / 0.34
medium	0.16 / 0.19	0.17 / 0.20	0.18 / 0.21
high	0.27 / 0.29	0.28 / 0.29	0.27 / 0.28
Cloud N. Hem. (AREA 2)	**T+24 30 levels / oper**	**T+72 30 levels / oper**	**T+120 30 levels / oper**
low	0.34 / 0.31	0.40 / 0.35	0.41 / 0.34
medium	0.15 / 0.17	0.17 / 0.20	0.19 / 0.22
high	0.22 / 0.24	0.23 / 0.26	0.23 / 0.26

The T+72 convective and dynamic accumulations from the trial and operational forecasts in the Northern Hemisphere (north of 30N) and for Area 2, meaned over the period 12Z 24/06/95 to 12Z 06/07/95, are compared in **Table 3.4** below. Each trial forecast showed a small increase in convective precipitation, mainly over land, with a smaller decrease in dynamic precipitation. The total increase was only about 1%.

TABLE 3.4. Comparison of total mean forecast precipitation accumulations in the Northern Hemisphere at T+72.

Mean precipitation at T+72 (kg/m^2/3days)	N.Hem (30N-90N) 30 levels / oper	N.Hem (Area 2) 30 levels / oper
Convective accumulation	3.9031 / 3.7314	3.9530 / 3.7894
Dynamic accumulation	3.2014 / 3.2939	2.6866 / 2.7938

B. THE TROPICS.

There was a noticeable impact on forecast upper winds, cloud and precipitation in the Tropics. Most of the marked impact on 250hPa and 100hPa winds in the Tropics was probably due to the error in the trial's vertical diffusion. Daily comparisons showed that the biggest differences in the 250hPa winds occurred along the equator between 0 and 150W. The mean 250hPa wind differences at T+24, calculated over the period 12Z 22/06/95 to 12Z 04/07/95, are shown in **FIGURE 3.5a**, with the largest changes in the Pacific just west of South

America. A comparison of the operational and trial forecasts , FIGURES 3.5 b/c respectively, showed that the effect was a slight decrease in the trial northeasterly winds in this region.

The biggest differences at 100hPa also occurred along the equator, this time to the south of India. FIGURE 3.6a highlights these differences at T+24 in the mean 100hPa winds over the period 12Z 22/06/94 to 12Z 04/07/95. A comparison of the individual forecasts shows that in the trial forecast, FIGURE 3.6c, the gradient of the easterly wind south of India is stronger and the mini westerly jet east of Africa on the equator is missing. These differences proved very difficult to assess due to lack of observations and also because similar differences appeared between the respective analyses.

The mean low,medium and high cloud fractions for the trial and operational forecasts in the Tropics are shown in Table 3.5 below. Each individual trial forecast showed an increase in low cloud and a comparison of the cloud cross sections in FIGURE 3.16 shows the increase was at 950hPa.

TABLE 3.5. Comparison of mean forecast layer cloud fractions in the Tropics

Cloud in Tropics (30N-30S)	T+24 30 levels / oper	T+72 30 levels / oper	T+120 30 levels / oper
low	0.15 / 0.10	0.17 / 0.10	0.17 / 0.10
medium	0.05 / 0.06	0.06 / 0.07	0.06 / 0.07
high	0.27 / 0.22	0.28 / 0.24	0.31 / 0.26

There was a marked impact on precipitation in the ITCZ in the Tropics, with an overall increase in convective precipitation and a much smaller decrease in dynamic. The overall increase in precipitation was about 3%. The T+72 convective and dynamic accumulations from the trial and operational forecasts, meaned over the period 12Z 24/06/95 to 12Z 06/07/95, are compared in Table 3.6 below. The increase in convective precipitation is explained by reference to the convective cloud cross sections, FIGURE 3,17.which indicate an increase in the trial convective cloud in the Tropics.

TABLE 3.6. Comparison of total mean forecast precipitation accumulations in the Tropics at T+72.

Mean precipitation at T+72 (kg/m^2/3days)	Tropics (30N-30S) 30 levels / oper
Convective accumulation	11.0323 / 10.6533
Dynamic accumulation	0.3519 / 0.3679

C. THE SOUTHERN HEMISPHERE

Whilst most differences in the Southern Hemisphere were still due to small positional, depth and pattern differences, there were also a significant number of small evolution changes. Both versions tended to predict more complex low pressure areas than reality. Large differences were often connected with these complex low pressure areas, with different centres being developed by the two versions. These were difficult to assess at T+120 due to lack of observations, and because both forecasts often had significant errors. Differences between the mean sea level pressure and 500hPa forecasts of > 8hPa and > 6dm were assessed and the results at T+120 are summarised in **Tables 3.7 and 3.8** below. These tables show that the overall assessment favoured the trial forecasts, especially at 500hPa..

TABLE 3.7. Subjective assessment of mean sea level pressure differences at T+120 - Southern Hemisphere. (Overall; Trial better 50, Equal 59, Oper better 42 occasions.)

Differences	Nr.	Trial better	equal	Oper better
Pattern -strength, direction of flow	61	29	10	22
Depth - depressions,troughs	26	10	4	12
Positional	24	9	11	4
Evolution	35	1	31	3
Pressure values	5	1	3	1

TABLE 3.8

Subjective assessment of 500hPa height differences at T+120 - Northern Hemisphere. (Overall; Trial better 44, Equal 29, Oper better 30 occasions.)

Differences	Nr.	Trial better	equal	Oper better
Pattern	50	30	3	17
Depth - cold pools,troughs	11	5	0	6
Positional	8	3	2	3
Evolution	20	0	20	0
Height values	14	6	4	4

Several large differences occurred in the prediction of depressions at T+120 in the South Atlantic, especially in the vicinity of the Falkland Islands. The analysis in FIGURE **3.7d** shows a deep depression, 958hpa, centred south of the Falkland Islands at 12Z 06/07/95. Both the trial and operational forecasts for T+120 verifying at this time, predicted a more complex low than that shown in the analysis, with more than one centre. The trial forecast, FIGURE **3.7a**, was closer to the analysed pattern, but its centre was too deep at 942hPa. The operational forecast of the low pressure area, FIGURE **3.7b**, was too complex with three centres being predicted.

Some large errors occurred connected with low pressure areas over New Zealand, with the trial version tending to over-deepen the centres. In the example given, the analysis for 12Z 29/06/94, FIGURE **3.8d**, shows a depression, depth 987hPa, centred over New Zealand. The operational forecast, FIGURE **3.8b**, was very accurate, predicting a centre of 982hPa in the correct position at T+120. The trial forecast, FIGURE **3.8a**, was still a good forecast for T+120 but it over-deepened the centre by 16hPa and the position was not so accurate.

Another source region of large forecast differences was the Southern Ocean to the south of Australia. In this region, the trial forecast was usually better. The analysis for 12Z 29/06/95, FIGURE **3.9d**, shows a depression, depth 988hpa, centred west of Tasmania. The trial forecast , FIGURE **3.9a**, was reasonably good at predicting a low in this area at T+120, although there was a positional error of 10-15 degrees and the predicted anticyclone to the south was too intense. The operational forecast, FIGURE **3.9b**, did not deepen the feature sufficiently, predicting a trough rather than a cut-off low.

The 500hPa analysis for the same time ,12Z 29/06/95, FIGURE **3.10d**, features a cold pool of 522dm in the same area to the west of Tasmania. Allowing for the positional error, the trial forecast for T+120, FIGURE **3.10a**, was far better in predicting a cold pool of 527dm in this region. In contrast, the operational forecast for T+120, FIGURE **3.10b**, had

a large error in predicting only a 540dm trough.

The T+72 trial forecast, verifying at 12Z 22/06/95, FIGURE **3.11a**, predicted a depression, 1007hPa, in the South Atlantic, close to Tristan da Cunha and Gough Island. In contrast, the operational forecast, FIGURE **3.11b**, only predicted a spot low 1019hPa. Verification was a problem since there were no observations from Tristan da Cunha on 22nd, and Gough Island was slightly too far south, although it reported some light rain between 09Z and 21Z. However, the verifying analysis for 12Z 22/06/95, FIGURE **3.11d**, did have a depression of 1011hPa in this position to justify the trial forecast.

Each trial forecast showed an increase in low cloud plus a smaller decrease in upper cloud. The mean low,medium and high cloud fractions for the trial and operational forecasts in the Southern Hemisphere (south of 30S) are compared in **Table 3.9** below. The increase in low cloud in the Southern Hemispere, FIGURE **3.4**, is small , fractions 0.1-0.3, but spread over the Oceans as well as land. The decrease in medium cloud shows up well in the cloud cross-sections, FIGURE **3.16**.

TABLE 3.9. Comparison of mean forecast layer cloud fractions in the Southern Hemisphere.

Cloud in S.Hem (30S-90S)	T+24 30 levels / oper	T+72 30 levels / oper	T+120 30 levels / oper
low	0.40 / 0.34	0.41 / 0.35	0.41 / 0.35
medium	0.31 / 0.36	0.31 / 0.36	0.31 / 0.36
high	0.34 / 0.34	0.36 / 0.37	0.36 / 0.37

The T+72 convective and dynamic accumulations from the trial and operational forecasts in the Southern Hemisphere (south of 30S), meaned over the period 12Z 24/06/95 to 12Z 06/07/95, are compared in **Table 3.10** below. Each trial forecast showed a small increase in convective precipitation and a smaller decrease in dynamic precipitation. The total increase was only about 1%.

TABLE 3.10. Comparison of total mean forecast precipitation accumulations in the Southern Hemisphere at T+72.

Mean precipitation at T+72 (kg/m^2/3days	S.Hem (30S-90S) 30 levels / oper
Convective accumulation	4.4368 / 4.2169
Dynamic accumulation	5.3669 / 5.5024

FIGURE 3.12 a/b respectively compare the trial and operational 250hPa jets in the Southern Hemisphere at T+24. They appear very similar, although the wind cross sections, FIGURE 3.14, indicate a small increase in the trial 'u' component at 200hPa.

D. ZONAL MEAN CROSS SECTIONS AND CHARTS

a) Temperature difference cross sections - FIGURE 3.13

The temperature cross sections at T+00 and T+72 show the zonal mean temperature differences at 13 standard levels between trial and operational analyses and forecasts, meaned over the period 12Z 21/06/95 to 12Z 03/07/95. The shaded areas indicate that the trial forecasts are colder. Unfortunately, the T+72 cross section indicates a slight worsening of the cold model bias.

b) Wind ('u' component) cross sections - FIGURE 3.14

These two cross sections show the operational and trial T+72 forecasts of the mean zonal 'u' wind components at 13 standard levels, meaned over the period 12Z 24/06/95 to 12Z 06/07/95 . The main difference is the increase in the 'u' component in the trial forecasts of the subtropical jet at 30S at 200hPa.

c) Wind ('v' component) cross sections - FIGURE 3.15

These two cross sections show the operational and trial T+72 forecasts of the mean zonal 'v' wind components at 13 standard levels, meaned over the period 12Z 24/06/95 to 12Z 06/07/95 . The main difference can be seen in the Tropics with the apparent shift southwards of the Hadley Cell maxima at 200hPa, but this may be due to the error in the trial's vertical diffusion. A similar difference was present between the two analyses.

d) Layer cloud cross sections - FIGURE 3.16

These two cross sections show the operational and trial T+72 forecasts of the mean zonal layer cloud fractions on model levels, meaned over the period 12Z 24/06/95 to 12Z 06/07/95 . The main differences ,(already mentioned in the previous sections) are an overall small increase in low cloud and decrease in upper cloud.

e) Convective cloud cross sections - FIGURE 3.17

These two cross sections show the operational and trial T+72 forecasts of the mean zonal convective cloud on model levels, meaned over the period 12Z 24/06/95 to 12Z 06/07/95. A comparison shows an increase in convection in the Tropics and also in the Southern Hemisphere at 40S.

f) Mean sea level pressure - FIGURES 3.18 and 3.19

There were occasional differences 5-8hPa between daily operational and trial analyses in the Southern Hemisphere, usually associated with the position or depth of a depression. The differences tended to be larger close to Antartica. Differences could be large over Antartica, both in the analysis, see **FIGURE 3.18a**, and in the forecast, reflecting differences in the method for calculating mean sea level pressure over high ground. The largest differences occurred in the forecast run from 12Z 20/6/95 corresponding the operational model change. **FIGURES 3.19 a/b** compare the operational and trial T+120 mean sea level pressure forecasts meaned over the period 12Z 26/06/95 to 12Z 08/07/95. At a glance they look almost identical but the differences are indicated in **FIGURE 3.18b**. The largest differences are in the Southern Hemisphere associated with the low pressure areas.

E. SUBJECTIVE CONCLUSIONS.

(i) Northern Hemisphere (north of 30N)
Neutral assessment - changes small
Small increase in low cloud mainly over land plus smaller decreases in upper cloud
Slight local increases in speed in the subtropical jet
Slight increase in convective precipitation over land.

(ii) Tropics (30N-30S)
Differences in upper winds over Equator may be due to incorrect diffusion
Small increase in convective cloud and precipitation.

(iii) Southern Hemisphere
Positive assessment
Forecast pattern better but sometimes overdone (i.e depressions too deep, ridges too strong)
Small increase in low cloud plus smaller decreases in upper cloud
Local slight increases in speed in the subtropical jet at 200hPa
Slight increase in convective precipitation.

4. SUBJECTIVE ASSESSMENT - LIMITED AREA MODEL

The impact of the increased vertical resolution on weather over the U.K. was negligible due to a period of mainly hot, dry weather associated with a persistent anticyclone.

Rainfall interest was confined to one or two thundery days at the beginning of July. and the rainfall examples shown are taken from one forecast, DT00Z 02/07/95. At 18Z 2nd July, a thundery trough was slow moving over Southern England, whilst a cold front over Southern Scotland was pushing slowly southwards. The radar image for this time, **FIGURE**

4.1a, shows the large area of rain in the south associated with the thundery trough. The cold front in the north was weakening but still giving some moderate rain over Northern Ireland. The T+18 operational and trial rainfall forecasts for 18Z are compared in **FIGURES 4.1 b/c** respectively. Both gave a similar forecast for the heavier rainfall in the south associated with the thundery trough, but the trial forecast predicted extra showers over Southern Scotland and Northern Ireland giving a better indication of the position of the cold front.

At 00Z 3rd July, the radar image, **FIGURE 4.2a**, shows a band of moderate to heavy rainfall stretching from East Anglia to the Channel Islands associated with the thundery trough. This was again well predicted by the T+24 forecasts, with the trial forecast, **FIGURE 4.2c**, having a slight advantage with the faster clearance from Brest. The weakening cold front over Northern England and North Wales was producing only patchy light rain and drizzle and the band of light showers predicted in the trial forecast was slightly overdone and too far north over Eastern England.

By 12Z 3rd July, the thundery trough had cleared Southeast England but there were still light showery outbreaks of rain on the weak cold front lying from the Wash to Cornwall as shown in the radar image, **FIGURE 4.3a**. Both T+36 forecasts predicted showers to be too widespread, but the trial forecast, **FIGURE 4.3c**, was worse in this respect.

All individual trial forecasts showed a small increase in convective precipitation plus a smaller decrease in dynamic precipitation. The T+36 total accumulations from the trial and operational forecasts, meaned over the period 12Z 22/06/95 to 12Z 04/07/95, are compared in **Table 4.1** below.

TABLE 4.1. Comparison of total mean forecast precipitation accumulations in the Limited Area Model at T+36.

Limited Area Model	Convective accumulation 30 levels / oper	Dynamic accumulation 30 levels / oper
Mean precipitation at T+36 (kg/m^2/36hours)	2.3622 / 2.2498	1.1753 / 1.1949

The mean low,medium and high cloud fractions for the trial and operational T+36 forecasts, meaned over the period 12Z 22/06/95 to 12Z 04/07/95, are compared in **Table 4.2** below. The increase of low cloud from 0.22 to 0.26 in the trial forecasts is shown by the shaded areas in **FIGURE 4.4.** The increase was small, 0.1 to 0.2, and mainly over land. This small increase of low cloud was noted in all individual trial forecasts but sadly this did not improve the low cloud forecast for the midsummer's day gloom case on 24th June.

TABLE 4.2. Comparison of mean forecast layer cloud fractions in the Limited Area Model.

Cloud at T+36 in LAM	low 30 levels / oper	medium 30 levels / oper	high 30 levels / oper
cloud fraction	0.2624 / 0.2225	0.1197 / 0.1381	0.2362 / 0.2422

The trial had minimal impact on mean sea level pressure forecasts even at T+36 due to the persistence of the large blocking anticylone over the British Isles. A comparison of the T+36 forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95 in FIGURE 4.5, show only very minor differences.

AT 500hPa, the two dominant features in the T+36 forecasts, see FIGURE 4.6, were the cold pool north of Newfoundland and the upper ridge over the British Isles. Minor differences in the upper trough over the Gulf of St Lawrence did verify better against the analysis for the trial forecasts in a comparison of rms errors in this region, but the differences are hard to spot by eye. The biggest difference between the 500hPa forecasts concerns the position of the 576dm contour to the east of the Caspian Sea. The trial forecast had lower rms errors in this region as well.

The T+36 mean 250hPa wind forecasts compared in FIGURE 4.7, are very similar. There is no evidence to suggest a stronger jet core in the Polar jet, shown from Hudson bay to New Foundland to Iceland during this period. Assessment of 29 individual trial and operational jets which differed by more than 5 knots slightly favoured the trial forecasts, (by 19 to 10). However, the subtropical jet, shown from the Mediterranean to Syria, was slighlty stronger in the trial forecasts.

SUBJECTIVE CONCLUSIONS - LIMITED AREA MODEL.

neutral impact on mean sea level pressure and 500hPa
small increase in low cloud
slight increase in convective precipitation.

5. CONCLUSIONS

From both the objective and subjective assessments it is clear that the enhanced vertical resolution can deliver some small but beneficial changes. The largest impacts are on winds and temperatures at upper levels. It is not ready for operational implementation at this stage. The problem of too much low cloud, particularly over N Hemispheric land, which causes the cold bias to become worse is less severe than the first trial (of July 1994). However the cause needs to be investigated and addressed. The deficiences associated with

the topmost levels in the first trial (larger interpolation errors and the exacerbated problems of the polar night stratosphere) have been avoided by the set of levels used here.

The beneficial impact in the southern hemisphere was generally rather larger than in the northern hemisphere. It may be expected that the extra resolution may be more effective in the winter hemisphere where the winds are stronger. A further test should be performed in the N Hemisphere autumn/winter prior to consideration of operational implementation.

REFERENCES

Bell R S, 1994

Revised moisture assimilation - Results of a parallel trial *FR Technical Report 132*

Milton SF, C A Wilson, and A Van der Wal, 1995:

A review of systematic errors in the global Unified Model used for NWP 1994-95 *FR Technical Report 162*

Milton SF, C A Wilson, O M Hammon and F Rawlins, 1995:

Impact of the new gravity wave drag scheme and orographic roughness in the Unified Model. III revised schemes and second parallel suite trial for the global and limited area models *FR Technical Report 139*

Simmons A J, 1994:

Some stratosheric aspects of model development at ECMWF. *ECMWF Workshop Proceedings on 'Stratosphere and Numerical Weather Prediction', November 1993*

Wilson C A, F Rawlins and O M Hammon, 1994:

Cause and cure of the superadiabatic lapse rate in the limited area and global models. *FR Technical Report 125*

Wilson C A and O M Hammon, 1994:

Trial of a longer timestep for physics in the global model. *FR Technical Report 112*

Wilson C A and O M Hammon , 1994

Trials of increased vertical resolution in the limited area model. *FR Technical Report 113*

Wilson C A and O M Hammon , 1995

Trials of increased vertical resolution in the global model. *FR Technical Report 114*

FIGURE CAPTIONS

Figure 3.1 - Mean sea level pressure charts for 12Z 24/06/95 over the North Pacific, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.2 - 500hPa height charts for 12Z 29/06/95 over the North Atlantic, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.3 - Mean 250hPa jets in the Northern Hemisphere over the period 12Z 22/06/95 to 12Z 04/07/95, comparing (a) trial T+24 forecast, (b) operational T+24 forecast.

Figure 3.4 - Shaded areas indicate increases in the mean low cloud fraction at T+72. Forecast meaned over the period 12Z 24/06/95 to 12Z 06/07/95.

Figure 3.5 - T+24 forecast 250hPa winds in the Tropics meaned over the period 12Z 22/06/95 to 12Z 04/07/95, showing (a) Differences (trial - operational), (b) Operational forecast, (c) Trial forecast.

Figure 3.6 - T+24 forecast 100hPa winds in the Tropics meaned over the period 12Z 22/06/95 to 12Z 04/07/95, showing (a) Differences (trial - operational), (b) Operational forecast, (c) Trial forecast.

Figure 3.7 - Mean sea level pressure charts for 12Z 06/07/95 over the South Atlantic near the Falkland Islands, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.8 - Mean sea level pressure charts for 12Z 29/06/95 over New Zealand, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.9 - Mean sea level pressure charts for 12Z 29/06/95 over the Southern Ocean, south of Australia, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.10 - 500hPa height charts for 12Z 29/06/95 over the Southern Ocean,south of Australia, comparing (a) trial T+120 forecast, (b) operational T+120 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.11 - Mean sea level pressure charts for 12Z 22/06/95 over the South Atlantic Ocean, near Tristan da Cunha, comparing (a) trial T+72 forecast, (b) operational T+72 forecast, (c) trial - operational differences, (d) verifying operational analysis.

Figure 3.12 - Mean 250hPa jets in the Southern Hemisphere over the period 12Z 22/06/95 to 12Z 04/07/95, comparing (a) trial T+24 forecast, (b) operational T+24 forecast.

Figure 3.13 - Zonal mean temperature cross sections, showing trial-operational differences. Shaded areas indicate that trial is colder.
(a) Analysis differences,meaned over period 12Z 21/06/95 - 12Z 03/07/95
(b) T+72 differences,meaned over period 12Z 24/06/95 - 12Z 06/07/95

Figure 3.14 - Zonal mean wind cross sections showing 'u' component, on 13 standard levels
(a) Operational T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95
(b) Trial T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95

Figure 3.15 - Zonal mean wind cross sections showing 'v' component, on 13 standard levels
(a) Operational T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95
(b) Trial T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95

Figure 3.16 - Zonal mean layer cloud cross sections on model levels
(a) Operational T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95
(b) Trial T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95

Figure 3.17 - Zonal mean convective cloud cross sections on model levels
(a) Operational T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95
(b) Trial T+72 forecast meaned over period 12Z 24/06/95 - 12Z 06/07/95

Figure 3.18 - Mean sea level pressure differences (negative differences shaded)
a) between trial and operational analyses, meaned over the period 12Z 21/06/95 to 12Z 03/07/95.
b) between trial and operational T+120 forecasts, meaned over the period 12Z 26/06/95 to 12Z 08/07/95.

Figure 3.19 - T+120 mean sea level pressure forecasts meaned over the period 12Z 26/06/95 to 12Z 08/07/95.
a) operational
b) trial

Figure 4.1.
(a) Radar image for 18Z 02/07/95
(b) Operational T+18 forecast DT 00Z 02/07/95 VT 18Z 02/07/95 mean sea level pressure and total precipitation rate
(c) Trial (30 Levels) T+18 forecast DT 00Z 02/07/95 VT 18Z 02/07/95 mean sea level pressure and total precipitation rate

Figure 4.2.
(a) Radar image for 00Z 03/07/95

(b) Operational T+24 forecast DT 00Z 02/07/95 VT 00Z 03/07/95 mean sea level pressure and total precipitation rate
(c) Trial (30 Levels) T+24 forecast DT 00Z 02/07/95 VT 00Z 03/07/95 mean sea level pressure and total precipitation rate

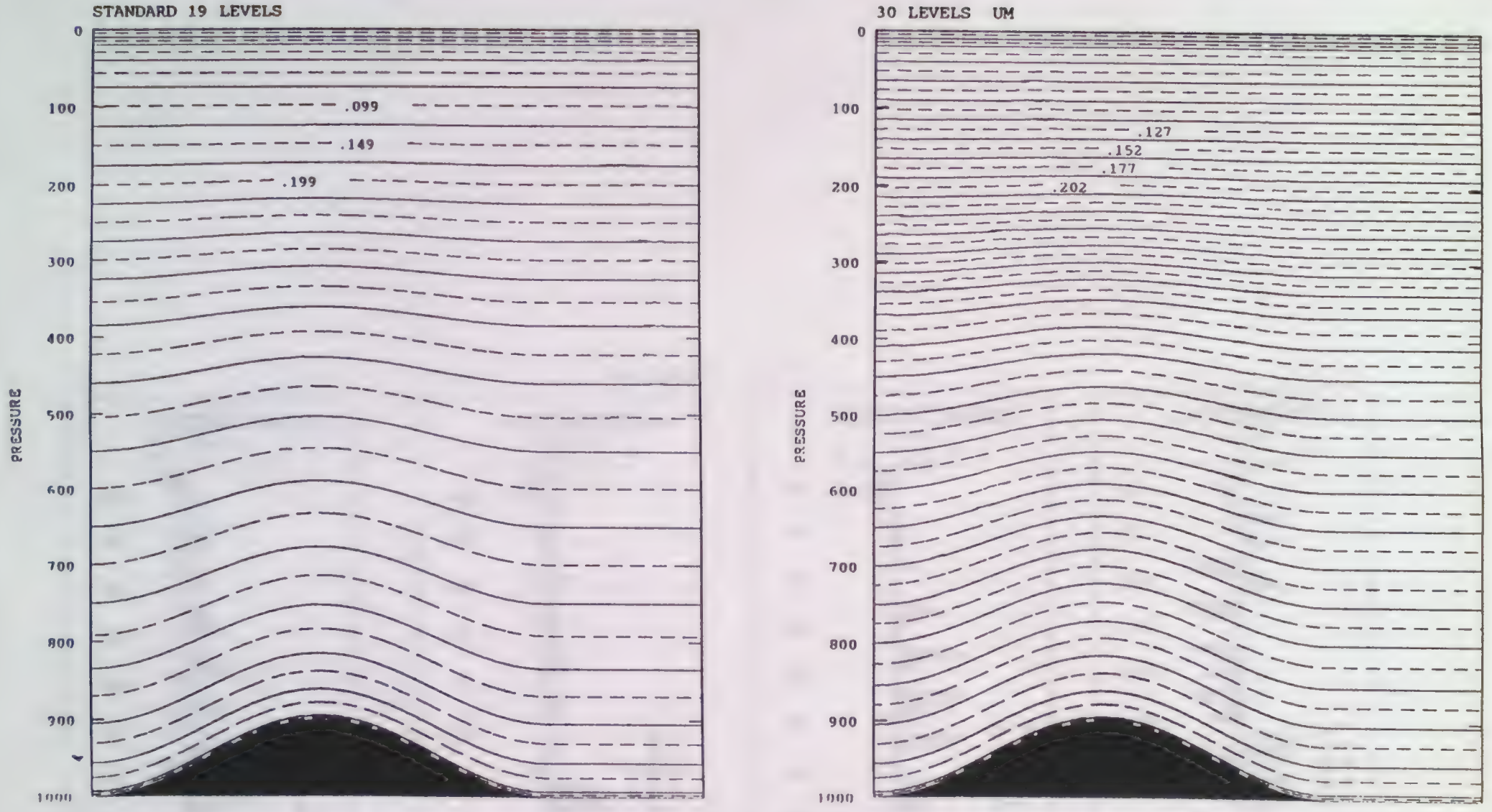
Figure 4.3.
(a) Radar image for 12Z 03/07/95
(b) Operational T+36 forecast DT 00Z 02/07/95 VT 12Z 03/07/95 mean sea level pressure and total precipitation rate
(c) Trial (30 Levels) T+236forecast DT 00Z 02/07/95 VT 12Z 03/07/95 mean sea level pressure and total precipitation rate

Figure 4.4.
Mean low cloud differences at T+36, meaned over the period 12Z 22/06/95 to 12Z 04/07/95. Shaded area shows increased low cloud in the trial forecasts.

Figure 4.5.
T+36 mean sea level pressure forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational (b) Trial (30 Levels)

Figure 4.6.
T+36 500hPa height forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational (b) Trial (30 Levels)

Figure 4.7.
T+36 250hPa wind forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational (b) Trial (30 Levels)


STANDARD 19 LEVELS
30 LEVELS UM
PRESSURE
0
100
200
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.149
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.177
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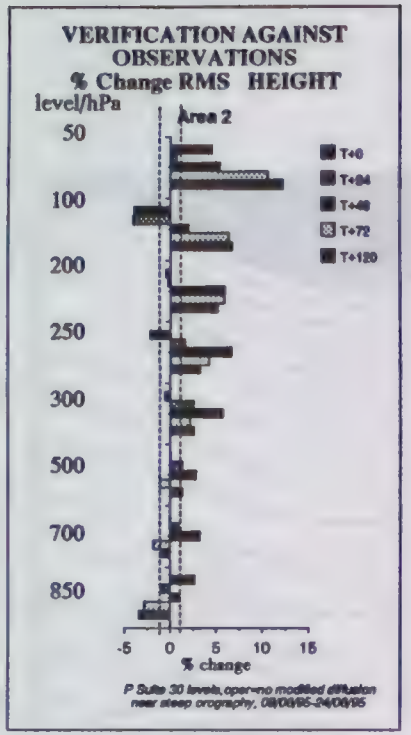
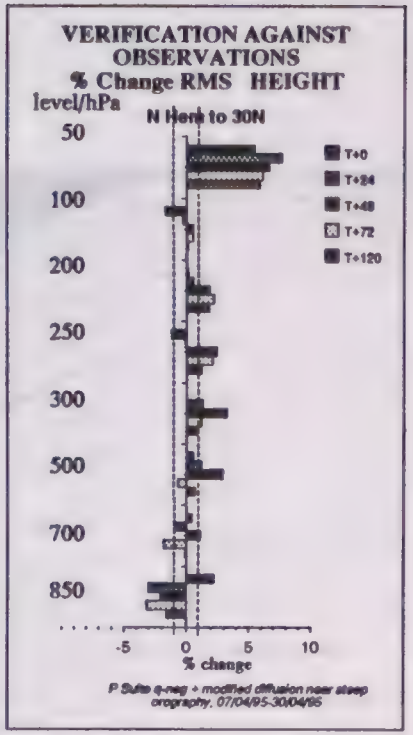
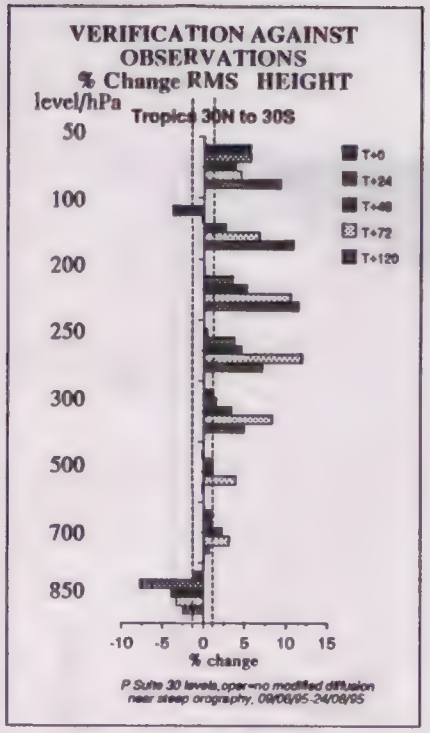
FIGURE 1.1


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
Area 2
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-5 0 5 10 15
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 08/06/95-24/06/95


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
N Hem to 30N
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-5 0 5 10
% change
P Suite q-neg + modified diffusion near steep orography, 07/04/95-30/04/95


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
Tropics 30N to 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-10 -5 0 5 10 15
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 09/06/95-24/06/95

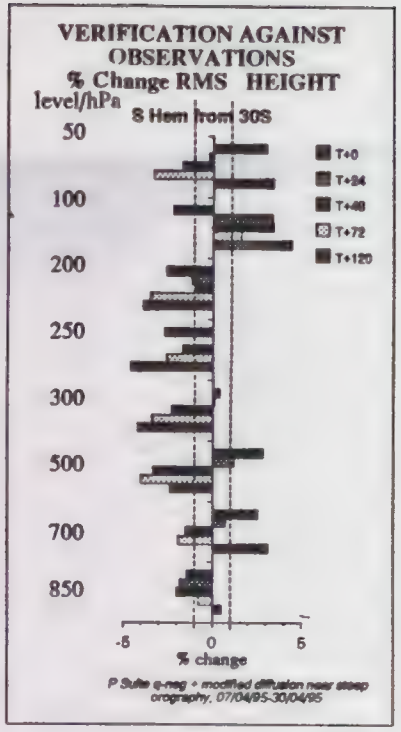
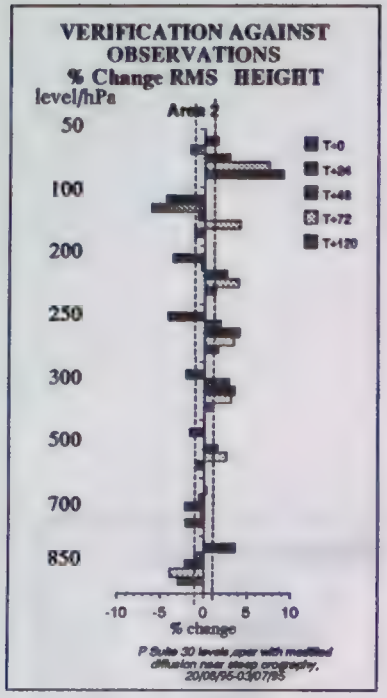
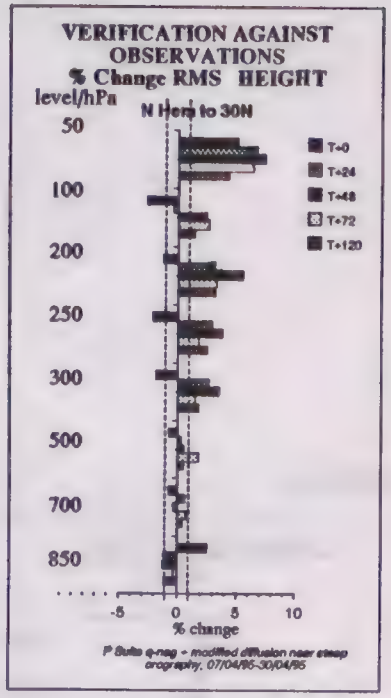
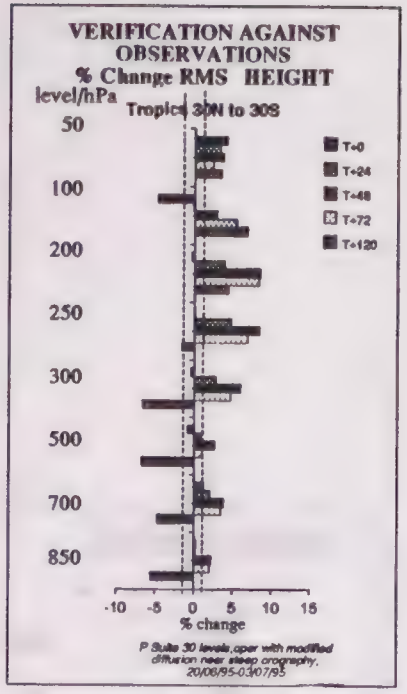

VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
S Hem from 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-5 0 5
% change
P Suite q-neg + modified diffusion near steep orography, 07/04/95-30/04/95

FIGURE 2.1a


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
Area 2
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
N Hem to 30N
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-5 0 5 10
% change
P Suite q-nag - modified diffusion near steep orography, 07/04/95-30/04/95


VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
Tropics 30N to 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-10 -5 0 5 10 15
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95

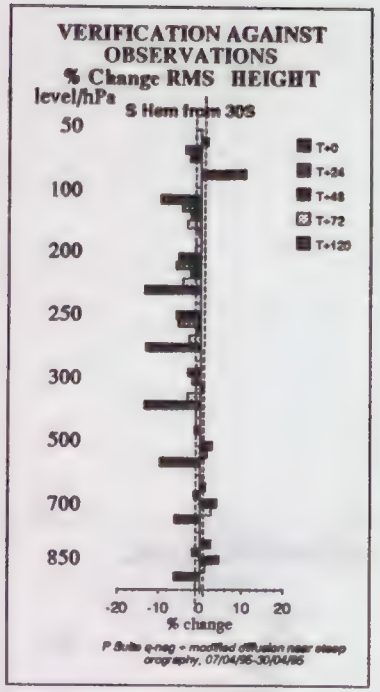

VERIFICATION AGAINST OBSERVATIONS
% Change RMS HEIGHT
level/hPa
S Hem from 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -10 0 10 20
% change
P Suite q-nag - modified diffusion near steep orography, 07/04/95-30/04/95

FIGURE 2.1b

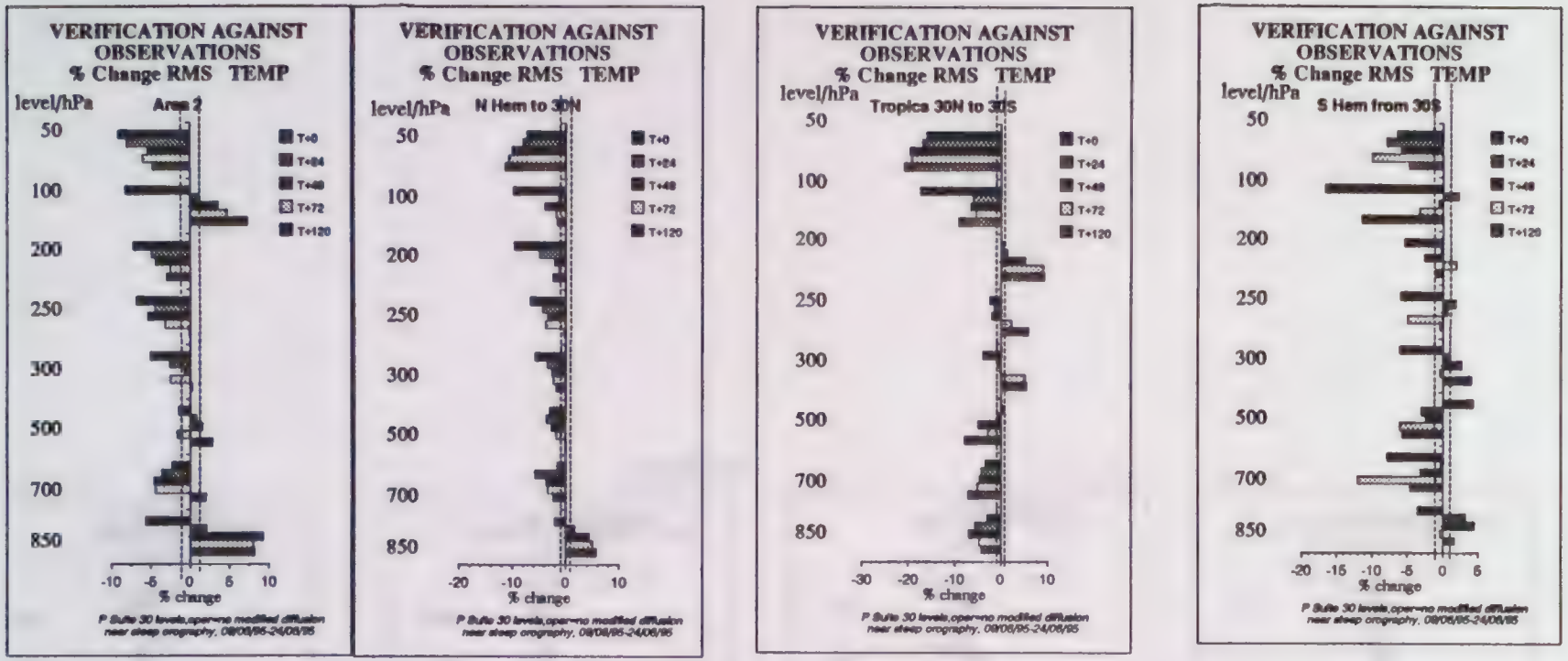
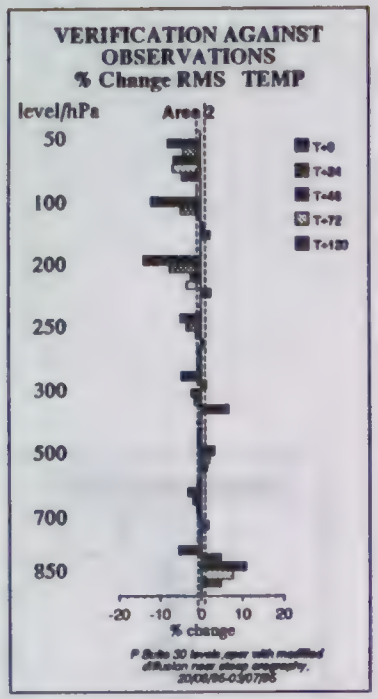
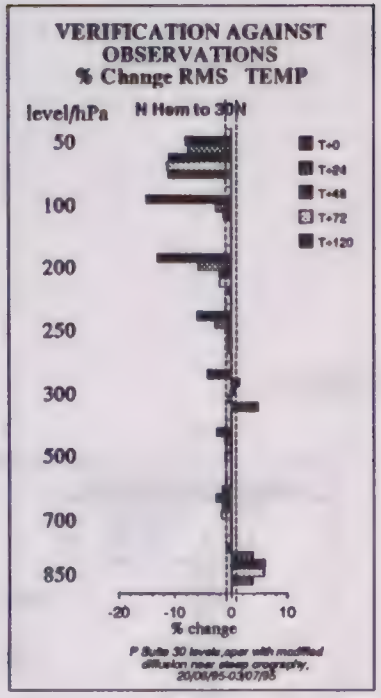
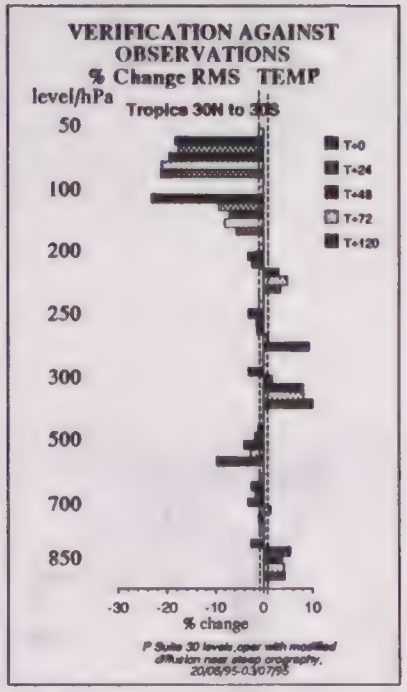

VERIFICATION AGAINST OBSERVATIONS
% Change RMS TEMP
level/hPa
Area 2
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 08/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS TEMP
level/hPa
N Hem to 30N
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -10 0 10
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 08/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS TEMP
level/hPa
Tropics 30N to 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-30 -20 -10 0 10
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 08/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS TEMP
level/hPa
S Hem from 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -15 -10 -5 0 5
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 08/06/95-24/06/95

FIGURE 2.2a


VERIFICATION AGAINST
OBSERVATIONS
% Change RMS TEMP
level/hPa
Area 2
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -10 0 10 20
% change
P Suite 30 levels,opar with modified diffusion near steep orography.
20/06/95-03/07/95


VERIFICATION AGAINST
OBSERVATIONS
% Change RMS TEMP
level/hPa
N Hem to 30N
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -10 0 10
% change
P Suite 30 levels,opar with modified diffusion near steep orography.
20/06/95-03/07/95


VERIFICATION AGAINST
OBSERVATIONS
% Change RMS TEMP
level/hPa
Tropics 30N to 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-30 -20 -10 0 10
% change
P Suite 30 levels,opar with modified diffusion near steep orography.
20/06/95-03/07/95

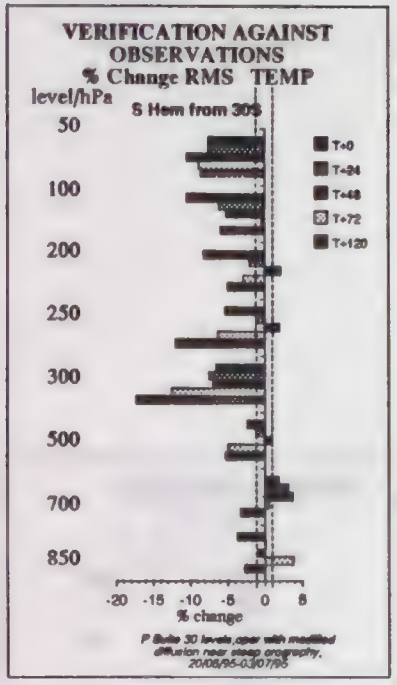

VERIFICATION AGAINST
OBSERVATIONS
% Change RMS TEMP
level/hPa
S Hem from 30S
50
100
200
250
300
500
700
850
T+0
T+24
T+48
T+72
T+120
-20 -15 -10 -5 0 5
% change
P Suite 30 levels,opar with modified diffusion near steep orography.
20/06/95-03/07/95

FIGURE 2.2b

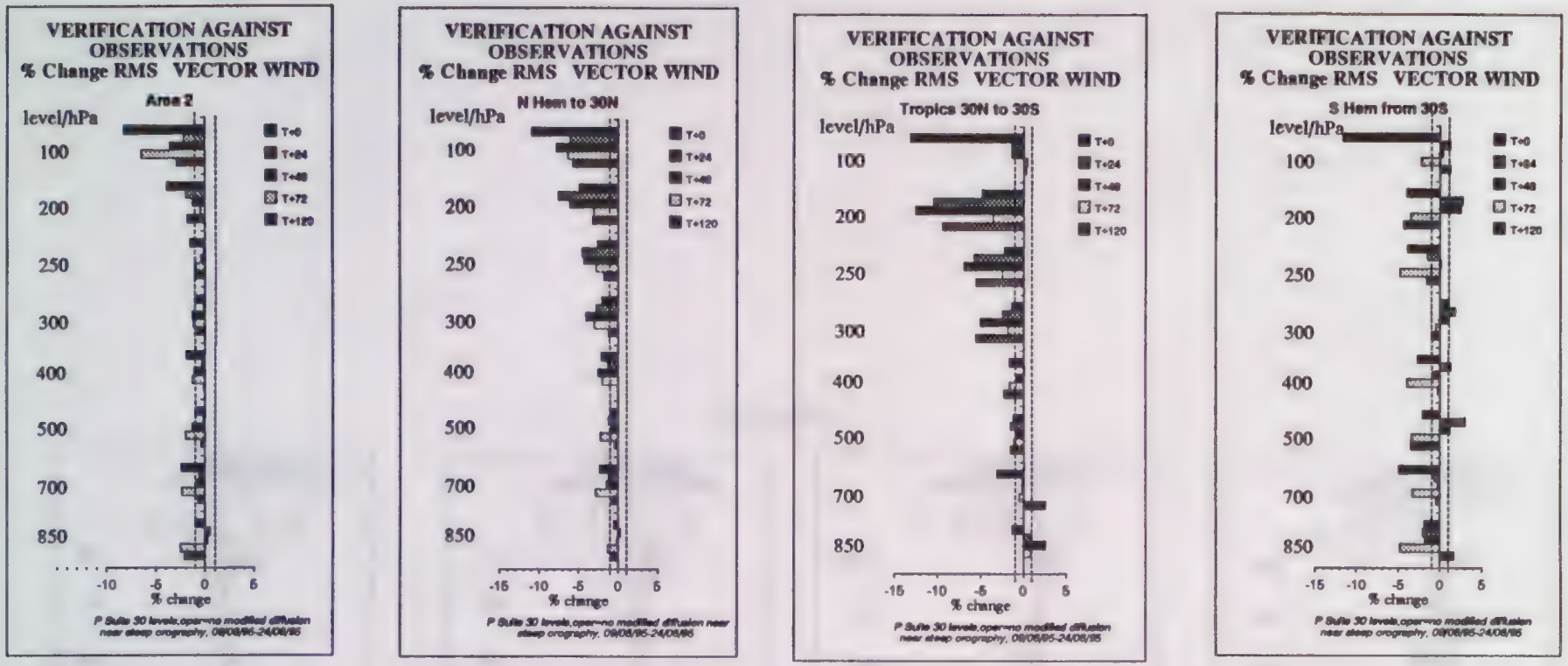

VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
Area 2
level/hPa
100
200
250
300
400
500
700
850
T+0
T+24
T+48
T+72
T+120
-10
-5
0
5
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 09/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
N Hem to 30N
level/hPa
100
200
250
300
400
500
700
850
T+0
T+24
T+48
T+72
T+120
-15
-10
-5
0
5
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 09/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
Tropics 30N to 30S
level/hPa
100
200
250
300
400
500
700
850
T+0
T+24
T+48
T+72
T+120
-15
-10
-5
0
5
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 09/06/95-24/06/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
S Hem from 30S
level/hPa
100
200
250
300
400
500
700
850
T+0
T+24
T+48
T+72
T+120
-15
-10
-5
0
5
% change
P Suite 30 levels,oper=no modified diffusion near steep orography, 09/06/95-24/06/95

FIGURE 2.3a

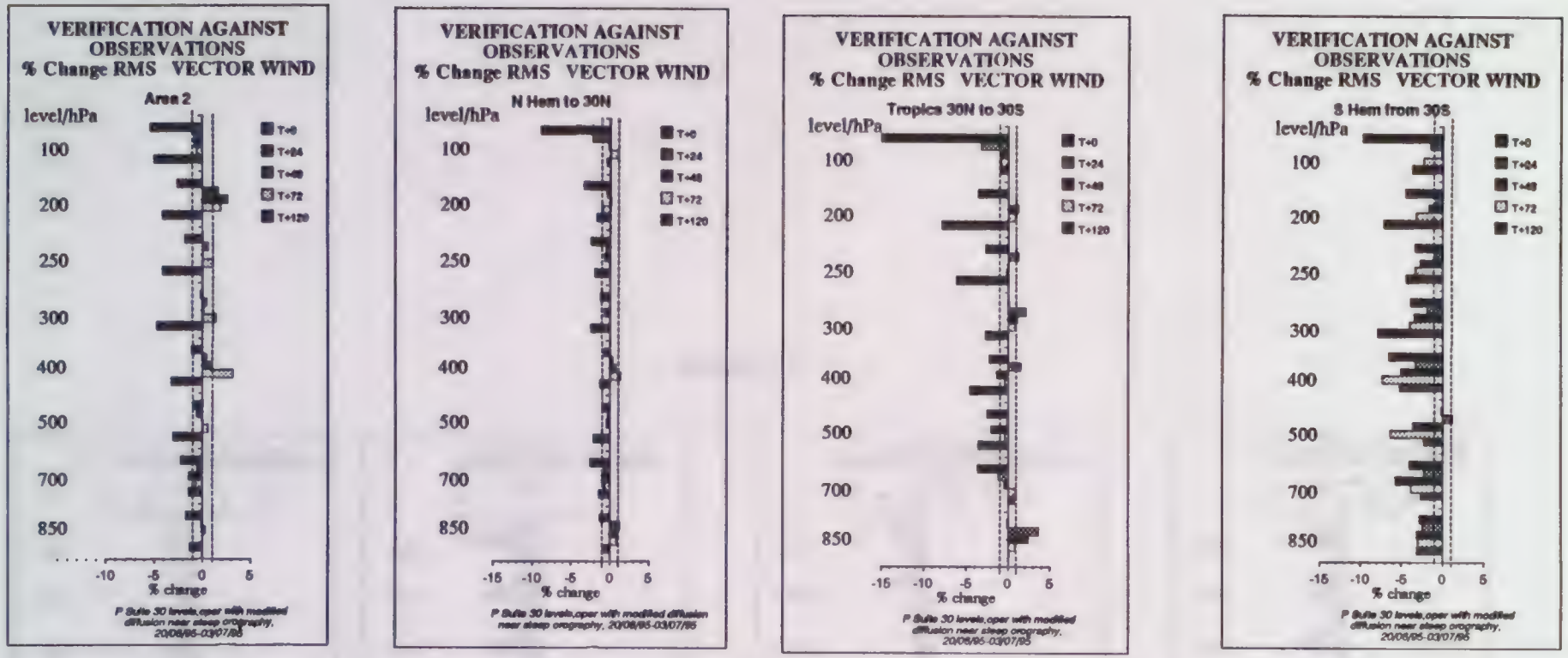

VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
Area 2
level/hPa
100
200
250
300
400
500
700
850
T+0
T+24
T+48
T+72
T+120
-10
-5
0
5
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
N Hem to 30N
level/hPa
-15
-10
-5
0
5
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
Tropics 30N to 30S
level/hPa
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95
VERIFICATION AGAINST OBSERVATIONS
% Change RMS VECTOR WIND
S Hem from 30S
level/hPa
% change
P Suite 30 levels,oper with modified diffusion near steep orography, 20/06/95-03/07/95

FIGURE 2.3b

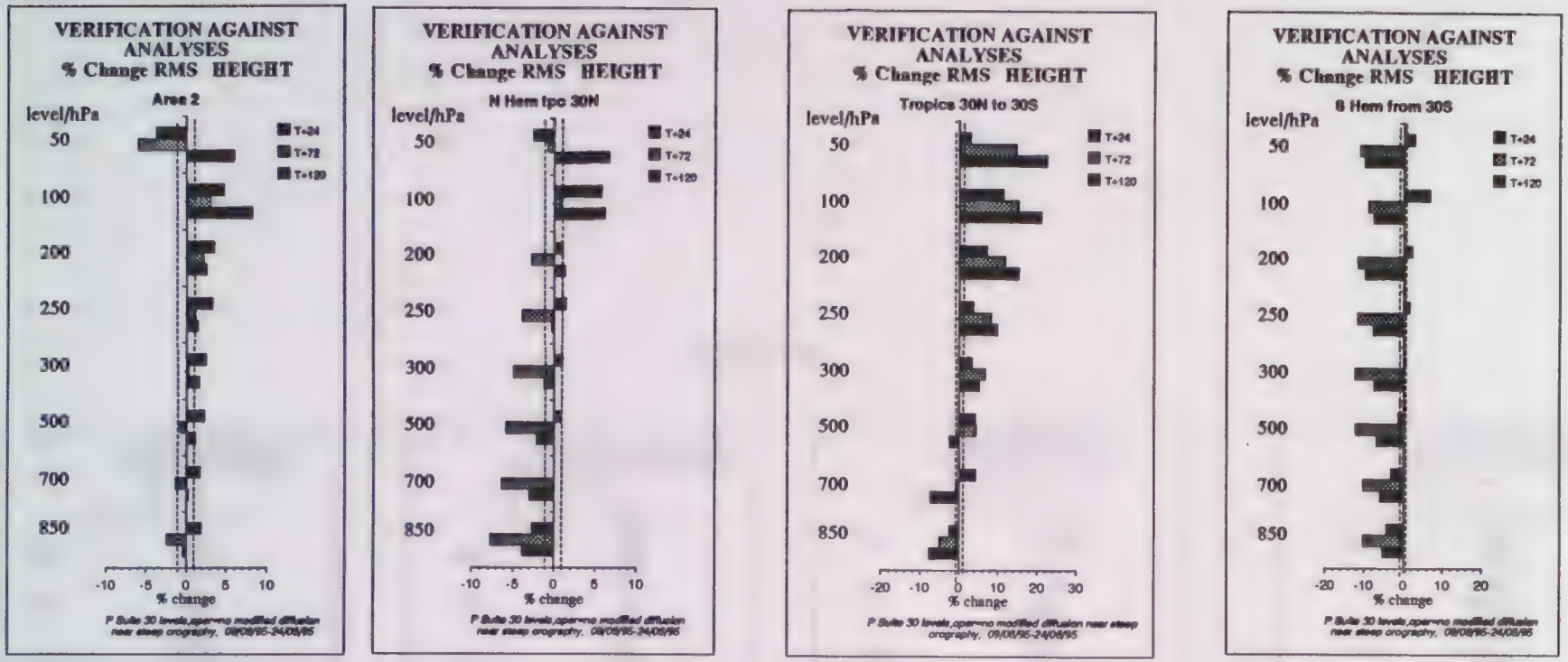

VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
Area 2
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,operno modified diffusion near steep orography, 09/08/95-24/08/95
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
N Hem tpo 30N
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,operno modified diffusion near steep orography, 09/08/95-24/08/95
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
Tropics 30N to 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-20 -10 0 10 20 30
% change
P Suite 30 levels,operno modified diffusion near steep orography, 09/08/95-24/08/95
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
S Hem from 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-20 -10 0 10 20
% change
P Suite 30 levels,operno modified diffusion near steep orography, 09/08/95-24/08/95

FIGURE 2.4a

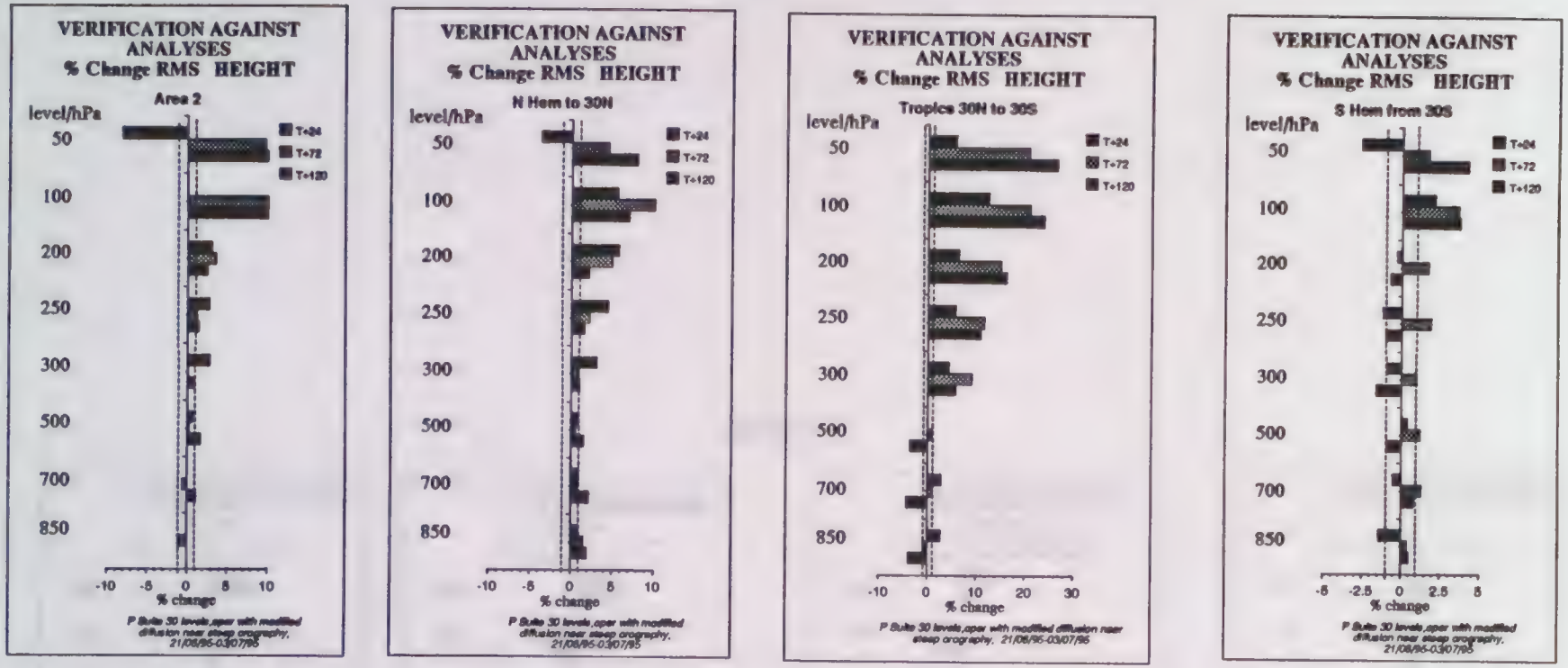

VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
Area 2
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,ope with modified diffusion near steep orography, 21/08/96-03/07/96
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
N Hem to 30N
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,ope with modified diffusion near steep orography, 21/08/96-03/07/96
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
Tropics 30N to 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 0 10 20 30
% change
P Suite 30 levels,ope with modified diffusion near steep orography, 21/08/96-03/07/96
VERIFICATION AGAINST ANALYSES
% Change RMS HEIGHT
S Hem from 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-5 -2.5 0 2.5 5
% change
P Suite 30 levels,ope with modified diffusion near steep orography, 21/08/96-03/07/96

FIGURE 2.4b

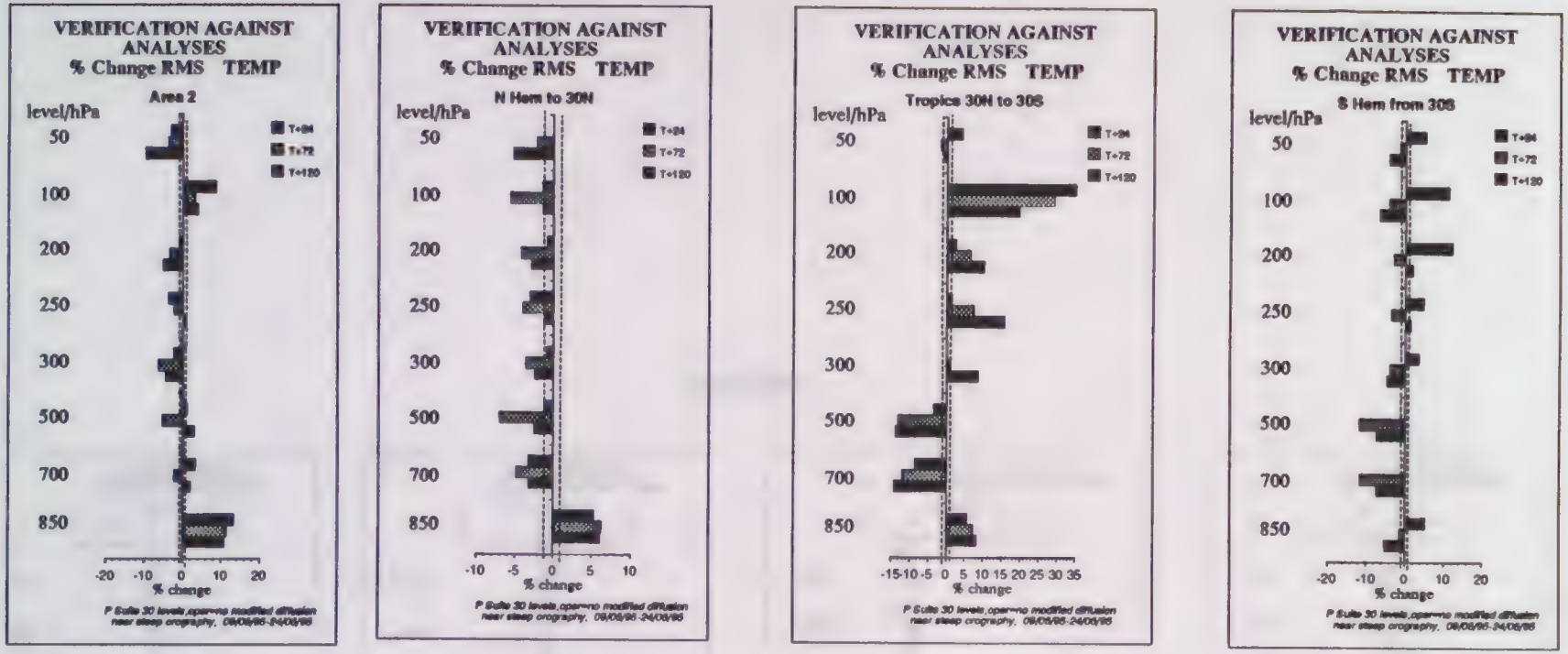

VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
Area 2
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-20 -10 0 10 20
% change
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
N Hem to 30N
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
Tropics 30N to 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-15 -10 -5 0 5 10 15 20 25 30 35
% change
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
S Hem from 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-20 -10 0 10 20
% change

FIGURE 2.5a

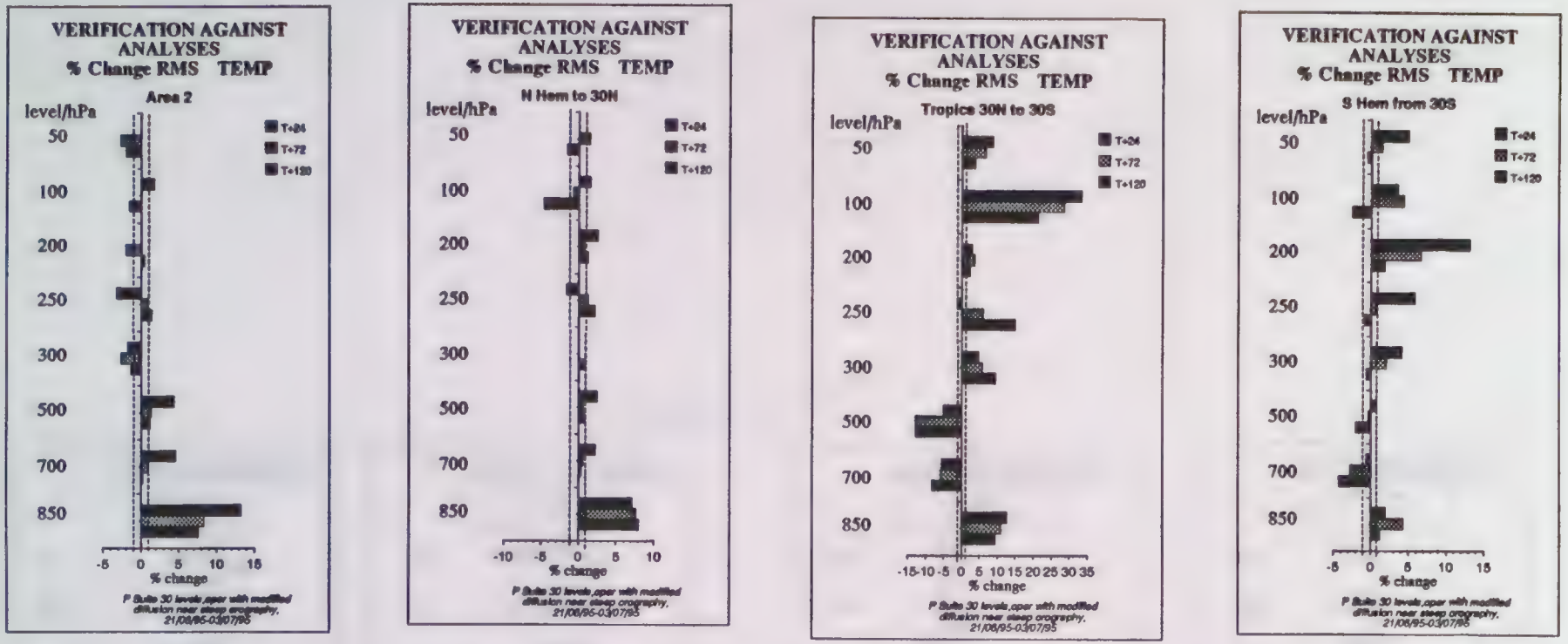

VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
Area 2
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-5 0 5 10 15
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
N Hem to 30N
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
Tropics 30N to 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-15 -10 -5 0 5 10 15 20 25 30 35
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95
VERIFICATION AGAINST ANALYSES
% Change RMS TEMP
S Hem from 30S
level/hPa
50
100
200
250
300
500
700
850
T+24
T+72
T+120
-5 0 5 10 15
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95

FIGURE 2.5b

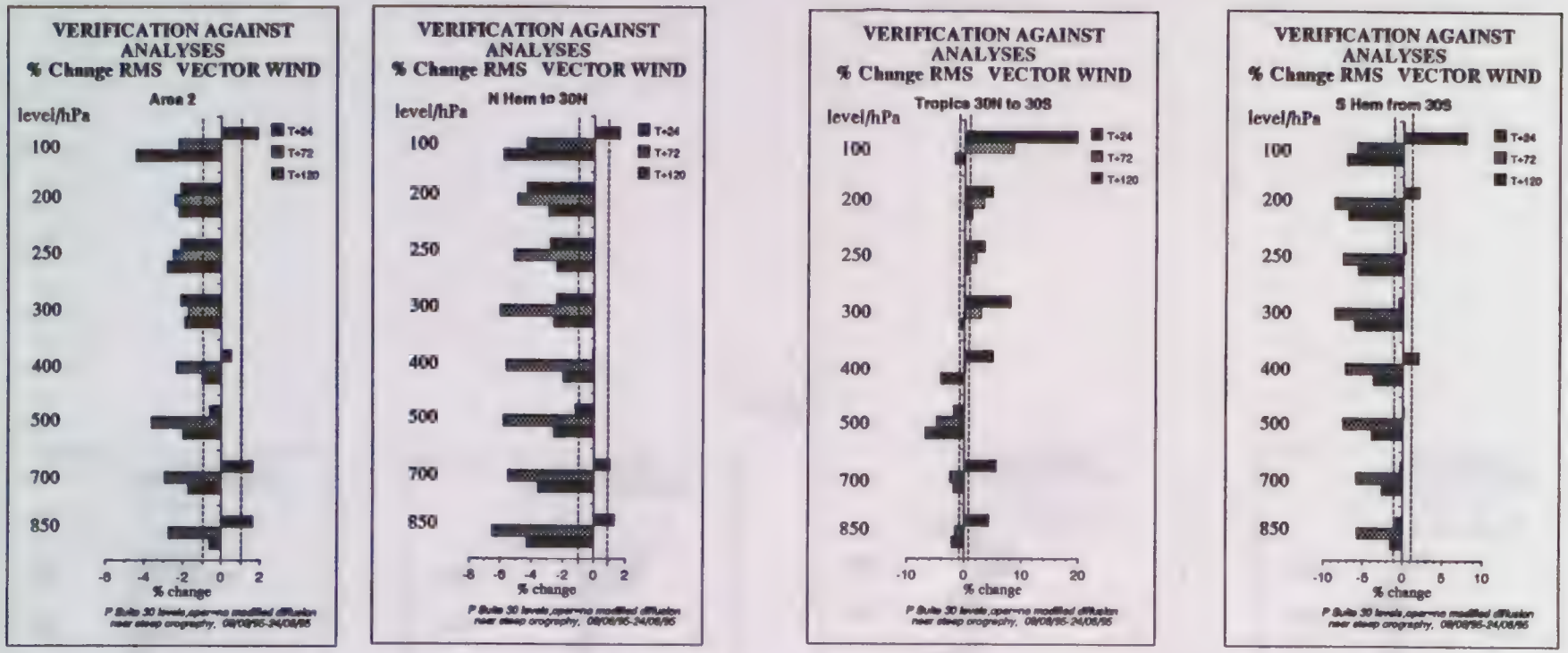
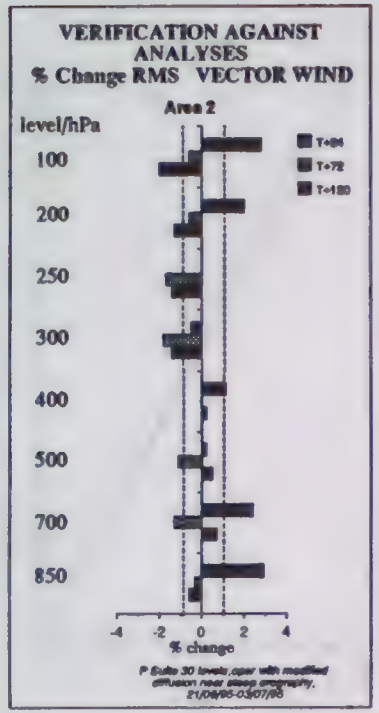
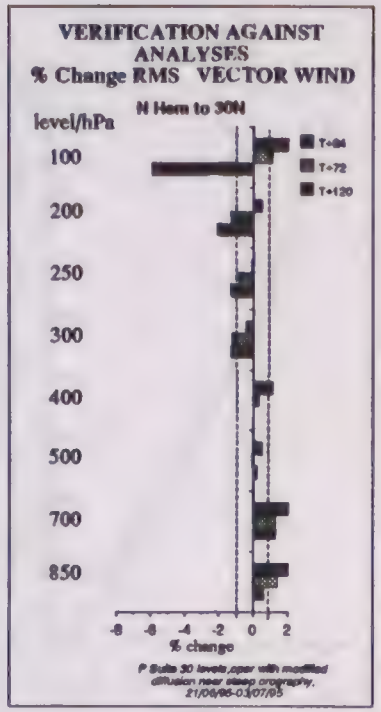
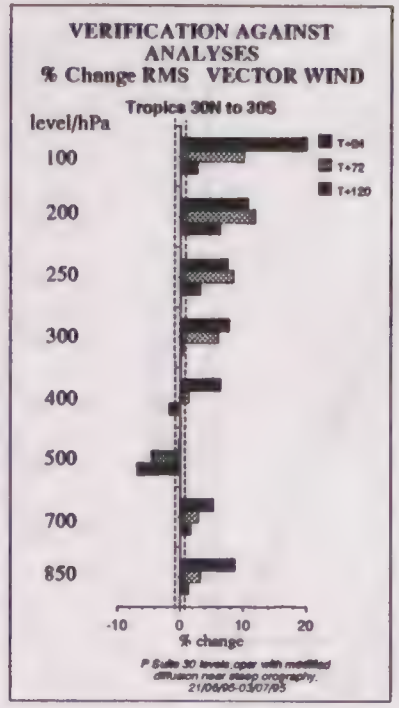

VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
Area 2
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-6 -4 -2 0 2
% change
VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
N Hem to 30N
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-8 -6 -4 -2 0 2
% change
VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
Tropics 30N to 30S
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-10 0 10 20
% change
VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
S Hem from 30S
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change

FIGURE 2.6a


VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
Area 2
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-4 -2 0 2 4
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95


VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
N Hem to 30N
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-8 -6 -4 -2 0 2
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95


VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
Tropics 30N to 30S
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-10 0 10 20
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95

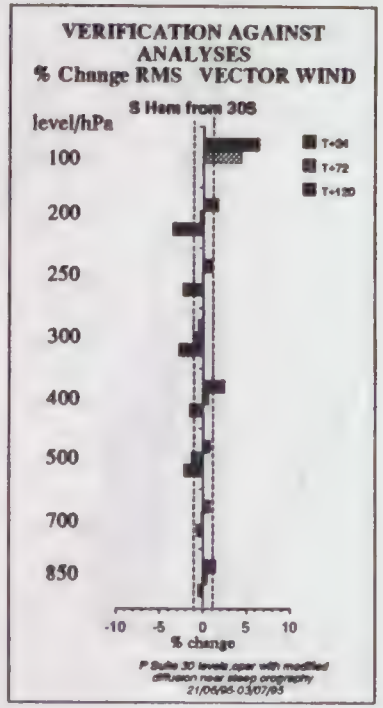

VERIFICATION AGAINST ANALYSES
% Change RMS VECTOR WIND
S Hem from 30S
level/hPa
100
200
250
300
400
500
700
850
T+24
T+72
T+120
-10 -5 0 5 10
% change
P Suite 30 levels,oper with modified diffusion near steep orography.
21/06/95-03/07/95

FIGURE 2.6b

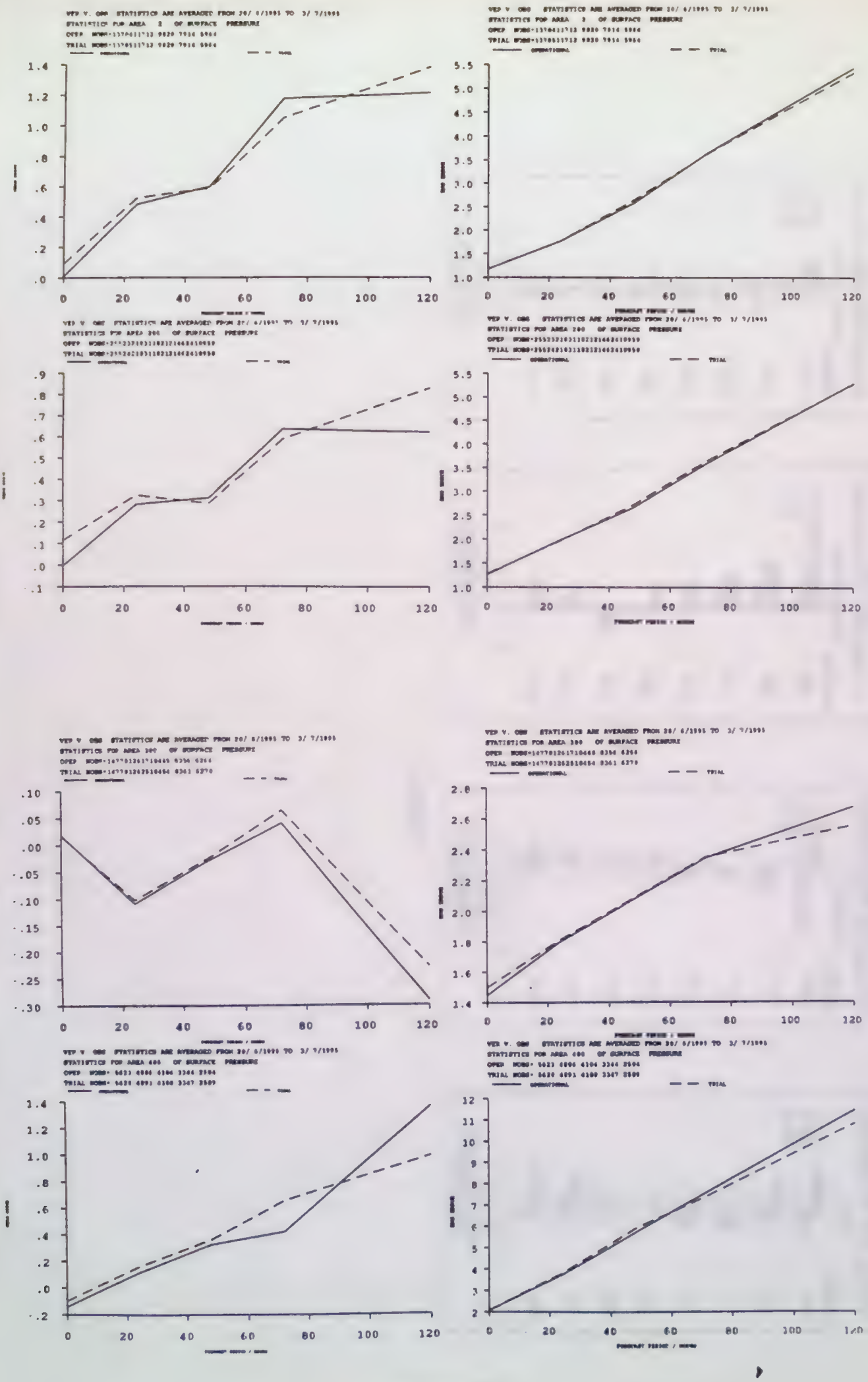
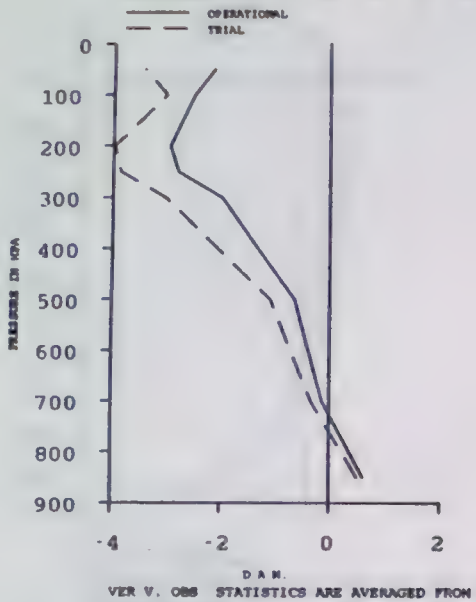
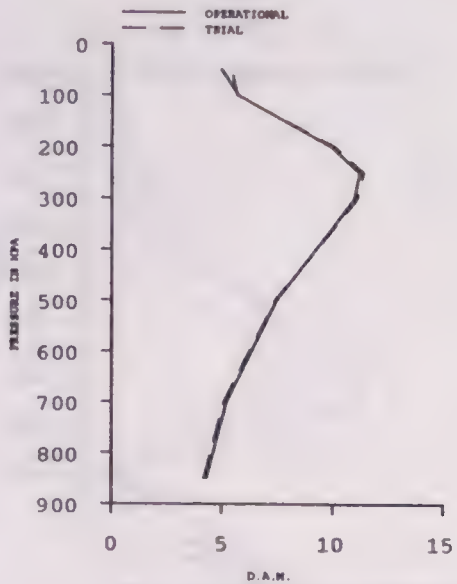


FIGURE 2.2.1

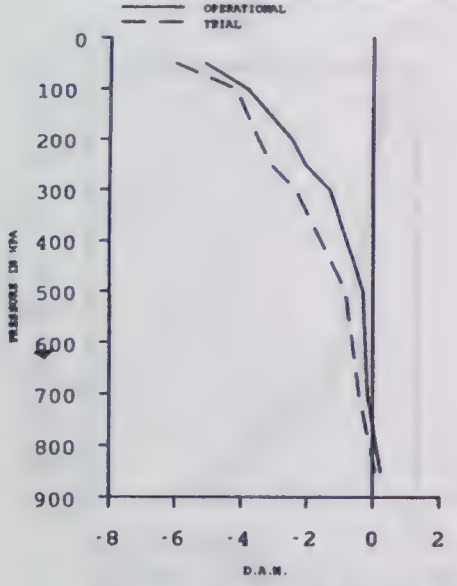
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 2 HEIGHT T+120
OPER NOBS= 830 819 823 819 817 818 805 660
TRIAL NOBS= 830 819 823 819 817 818 805 660



VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 2 HEIGHT T+120



VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 HEIGHT T+120
OPER NOBS= 2031 1993 2022 1990 1986 1984 1916 1658
TRIAL NOBS= 2031 1994 2022 1991 1986 1984 1916 1652



VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 HEIGHT T+120

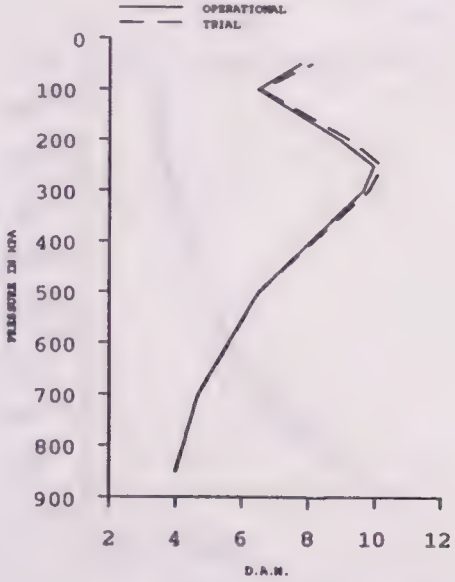


FIGURE 2.2.2

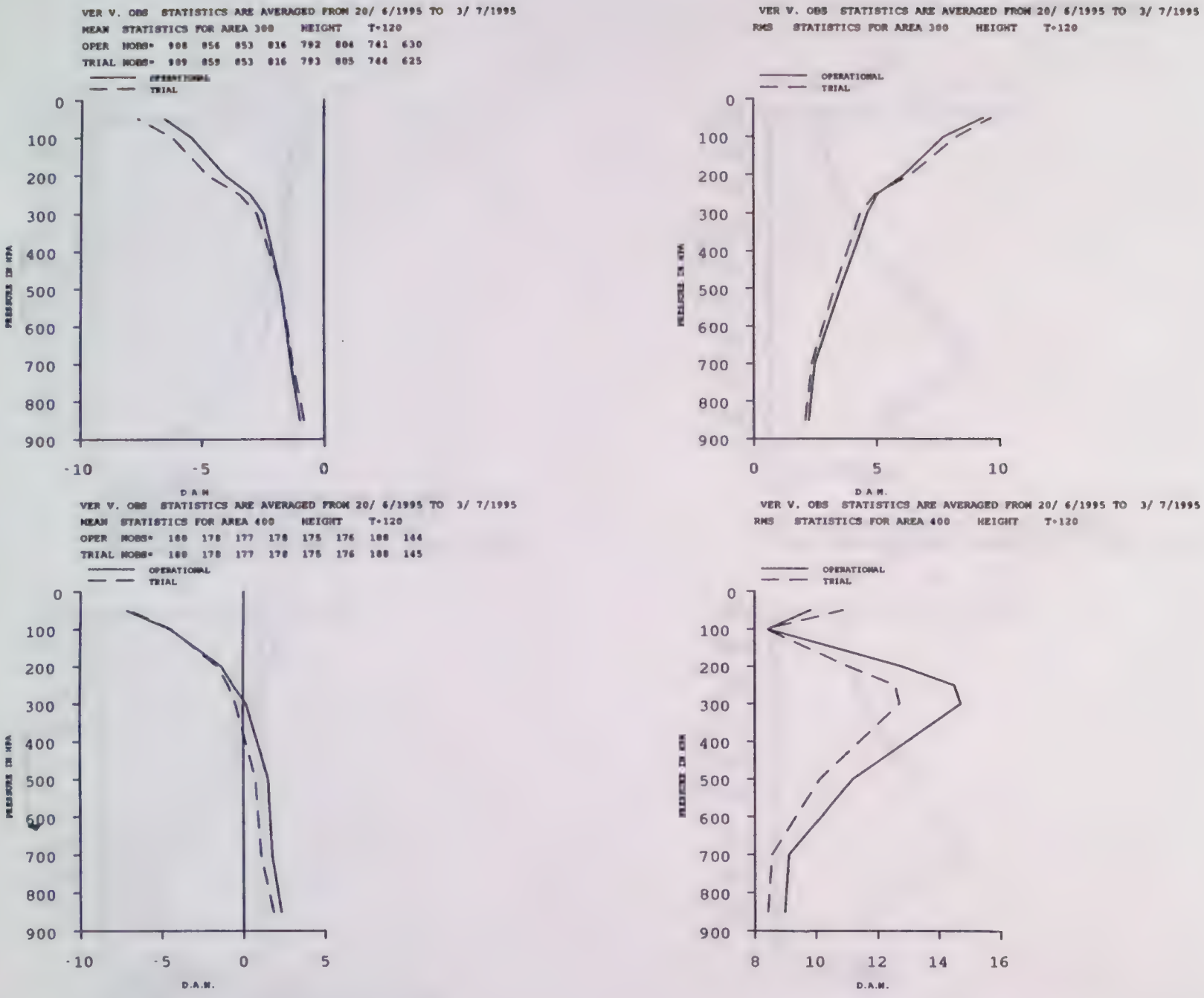

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 HEIGHT T+120
OPER NOBS= 908 856 853 816 792 804 741 630
TRIAL NOBS= 909 859 853 816 793 805 744 625
OPERATIONAL
TRIAL
PRESSURE IN MBA
D A M
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 HEIGHT T+120
OPERATIONAL
TRIAL
PRESSURE IN MBA
D A M.
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 HEIGHT T+120
OPER NOBS= 180 178 177 178 175 176 188 144
TRIAL NOBS= 180 178 177 178 175 176 188 145
OPERATIONAL
TRIAL
PRESSURE IN MBA
D.A.M.
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 HEIGHT T+120
OPERATIONAL
TRIAL
PRESSURE IN MBA
D.A.M.

FIGURE 2.2.3

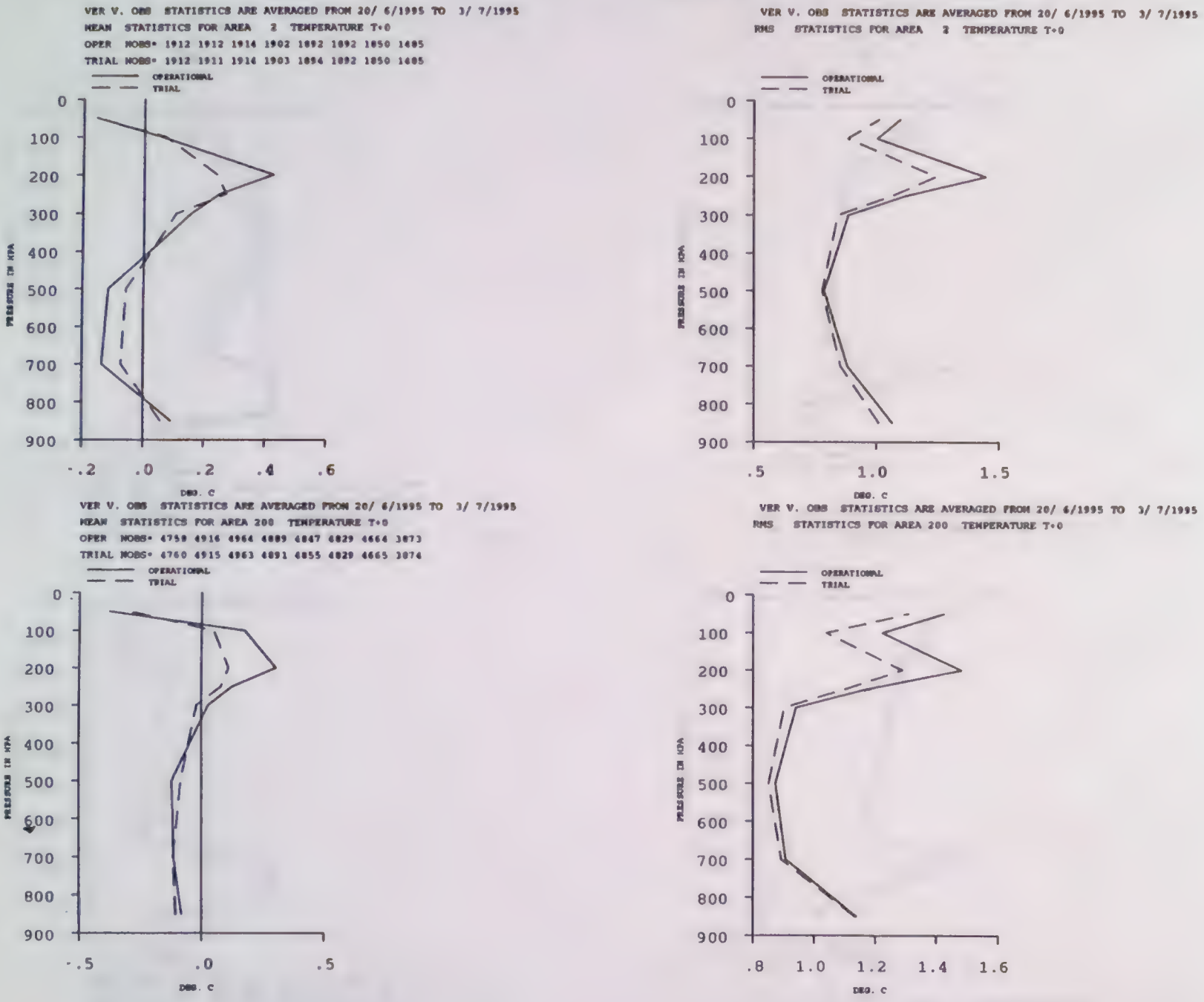

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 2 TEMPERATURE T+0
OPER NOBS= 1912 1912 1914 1902 1892 1892 1850 1485
TRIAL NOBS= 1912 1911 1914 1903 1894 1892 1850 1485
OPERATIONAL
TRIAL
PRESSURE IN HPA
0
100
200
300
400
500
600
700
800
900
-.2
.0
.2
.4
.6
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 2 TEMPERATURE T+0
OPERATIONAL
TRIAL
PRESSURE IN HPA
.5
1.0
1.5
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 TEMPERATURE T+0
OPER NOBS= 4758 4916 4964 4889 4847 4829 4664 3873
TRIAL NOBS= 4760 4915 4963 4891 4855 4829 4665 3874
OPERATIONAL
TRIAL
PRESSURE IN HPA
-.5
.0
.5
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 TEMPERATURE T+0
OPERATIONAL
TRIAL
PRESSURE IN HPA
.8
1.0
1.2
1.4
1.6
DEG. C

FIGURE 2.2.4

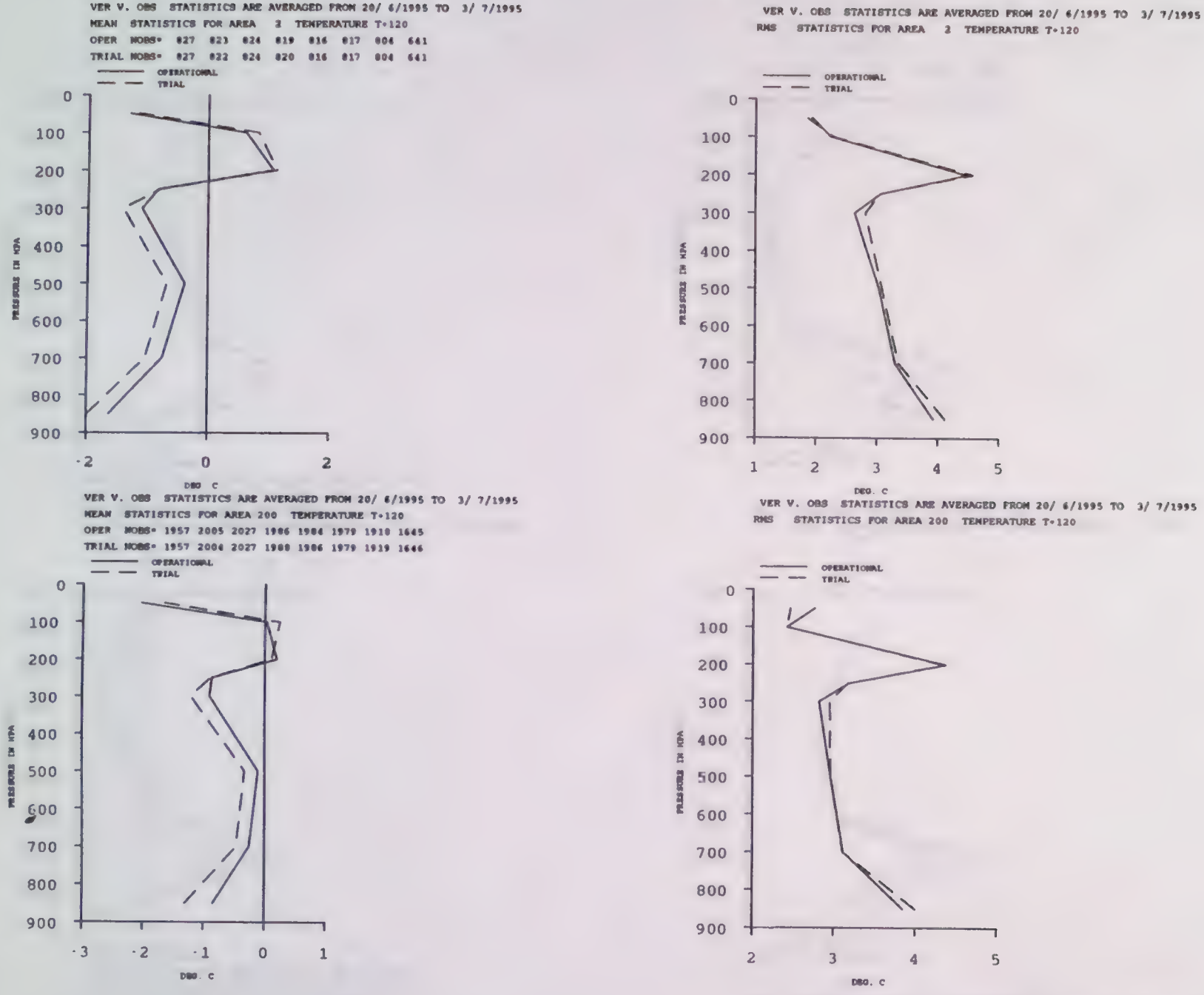

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 2 TEMPERATURE T+120
OPER NOBS= 827 823 824 819 816 817 804 641
TRIAL NOBS= 827 822 824 820 816 817 804 641
OPERATIONAL
TRIAL
PRESSURE IN HPA
0
100
200
300
400
500
600
700
800
900
-2
0
2
DEG C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 2 TEMPERATURE T+120
OPERATIONAL
TRIAL
PRESSURE IN HPA
1
2
3
4
5
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 TEMPERATURE T+120
OPER NOBS= 1957 2005 2027 1986 1984 1979 1918 1645
TRIAL NOBS= 1957 2004 2027 1988 1986 1979 1919 1646
OPERATIONAL
TRIAL
PRESSURE IN HPA
-3
-2
-1
0
1
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 TEMPERATURE T+120
OPERATIONAL
TRIAL
PRESSURE IN HPA
2
3
4
5
DEG. C

FIGURE 2.2.5

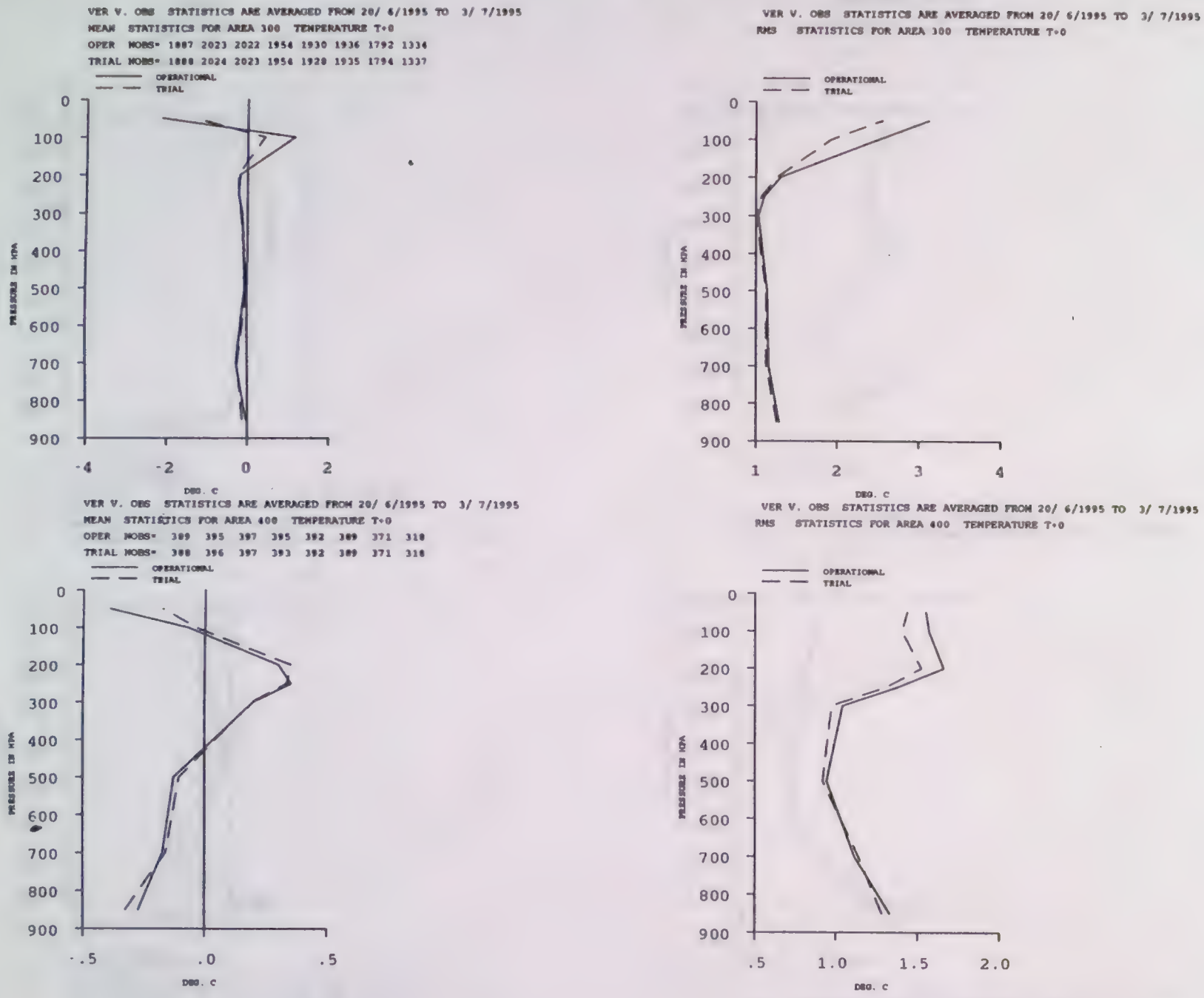

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 TEMPERATURE T+0
OPER NOBS= 1807 2023 2022 1954 1930 1936 1792 1334
TRIAL NOBS= 1808 2024 2023 1954 1920 1935 1794 1337
OPERATIONAL
TRIAL
PRESSURE IN HPA
0
100
200
300
400
500
600
700
800
900
-4
-2
0
2
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 TEMPERATURE T+0
OPERATIONAL
TRIAL
PRESSURE IN HPA
1
2
3
4
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 TEMPERATURE T+0
OPER NOBS= 389 395 397 395 392 389 371 318
TRIAL NOBS= 388 396 397 393 392 389 371 318
OPERATIONAL
TRIAL
PRESSURE IN HPA
-.5
.0
.5
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 TEMPERATURE T+0
OPERATIONAL
TRIAL
PRESSURE IN HPA
.5
1.0
1.5
2.0
DEG. C

FIGURE 2.2.6

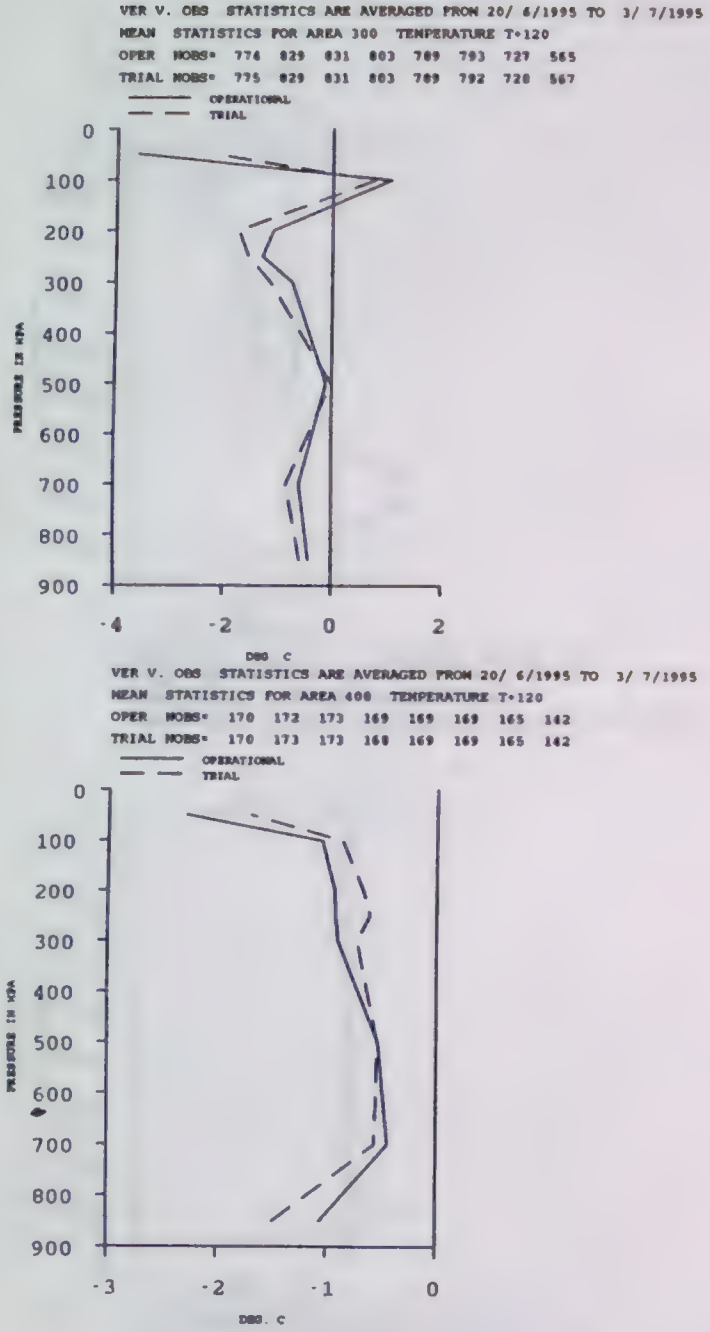

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 TEMPERATURE T+120
OPER NOBS= 774 829 831 803 789 793 727 565
TRIAL NOBS= 775 829 831 803 789 792 728 567
OPERATIONAL
TRIAL
PRESSURE IN MBA
DEG C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 TEMPERATURE T+120
OPER NOBS= 170 172 173 169 169 169 165 142
TRIAL NOBS= 170 173 173 169 169 169 165 142
OPERATIONAL
TRIAL
PRESSURE IN MBA
DEG. C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 TEMPERATURE T+120
OPERATIONAL
TRIAL
PRESSURE IN MBA
DEG C
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 TEMPERATURE T+120
OPERATIONAL
TRIAL
PRESSURE IN MBA
DEG. C

FIGURE 2.2.7

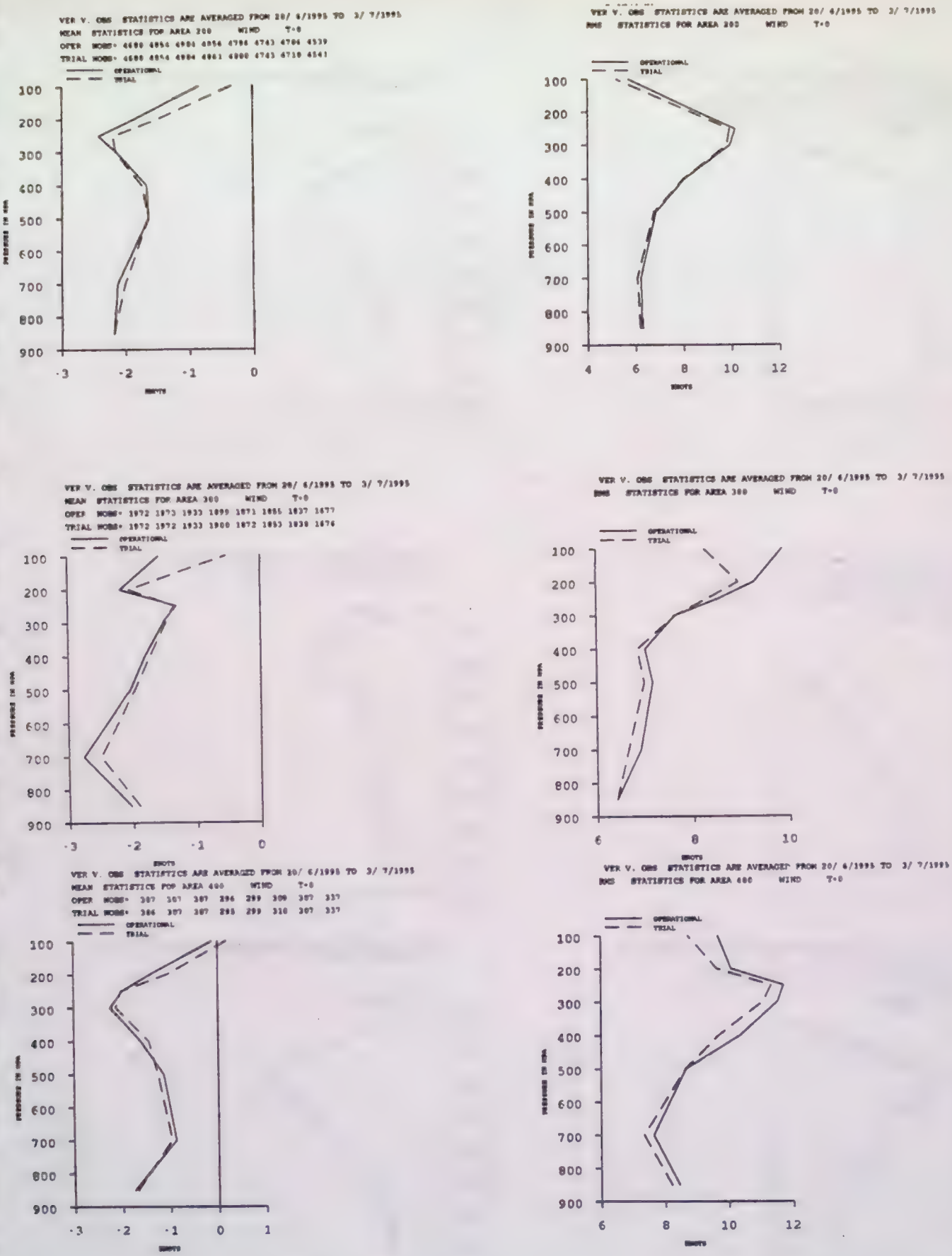
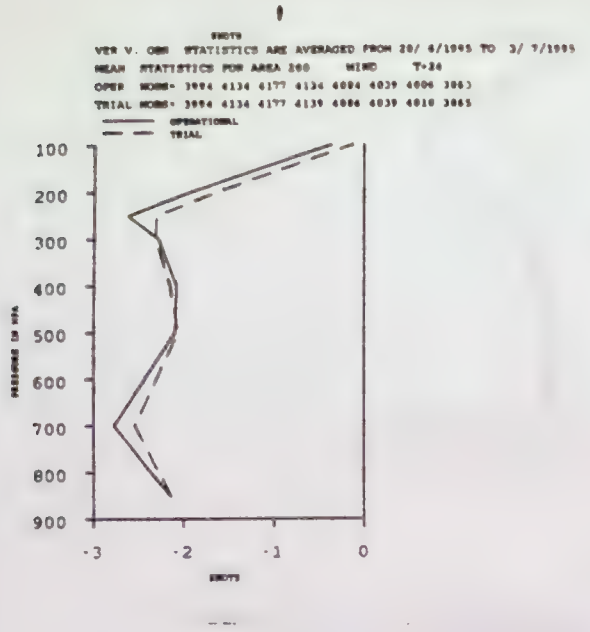
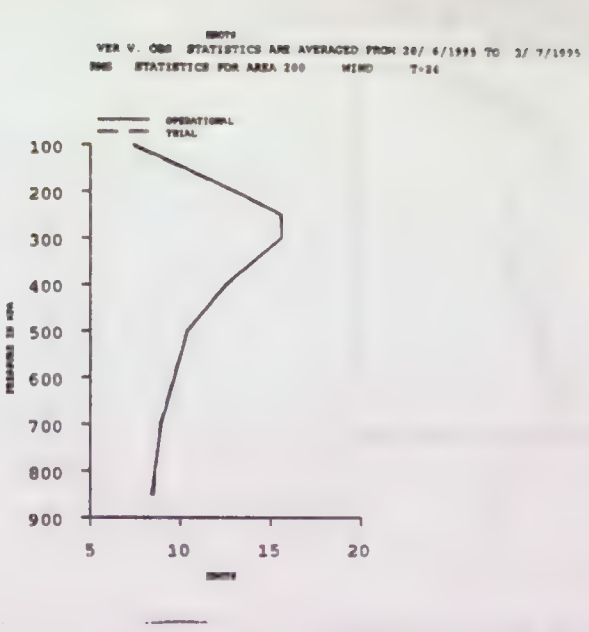
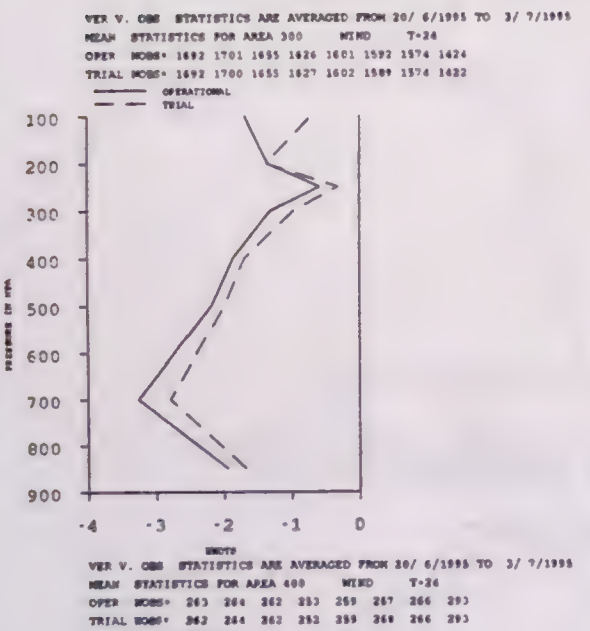
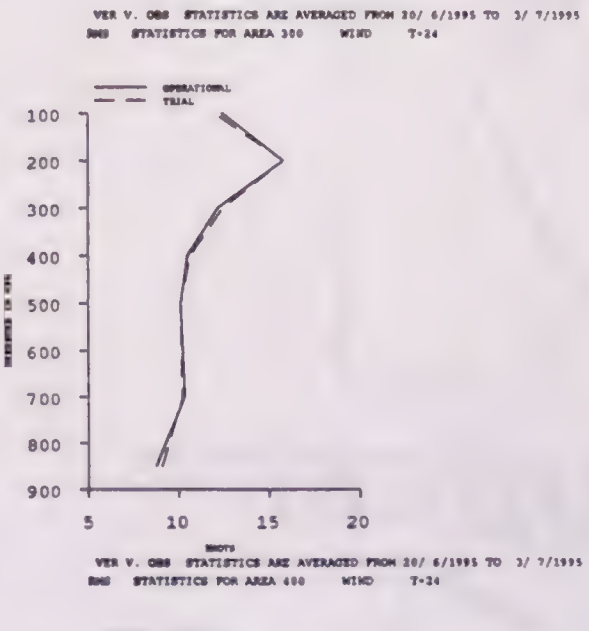

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 WIND T=0
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 WIND T=0
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 WIND T=0
OPER NOBS= 1972 1973 1933 1899 1871 1855 1837 1677
TRIAL NOBS= 1972 1972 1933 1900 1872 1853 1838 1676
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 WIND T=0
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 WIND T=0
OPER NOBS= 307 307 307 296 299 309 307 337
TRIAL NOBS= 306 307 307 295 299 310 307 337
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 WIND T=0
OPERATIONAL
TRIAL
PRESSURE IN MPA
KNOTS

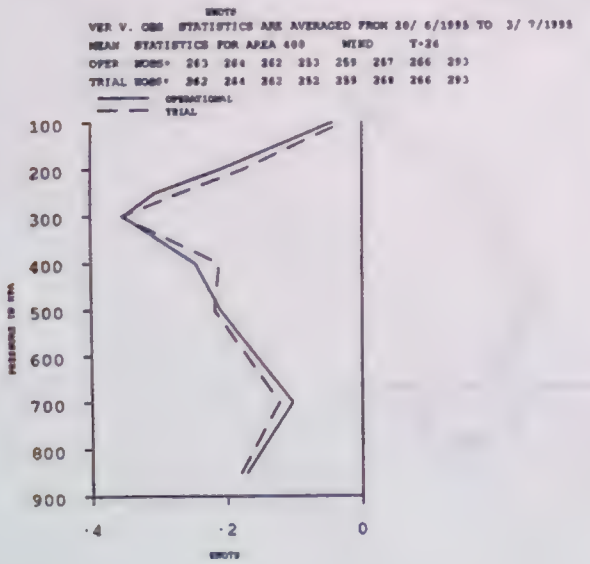
FIGURE 2.7


KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 WIND T+24
OPER NOBS= 3994 4134 4177 4134 4004 4039 4006 3863
TRIAL NOBS= 3994 4134 4177 4139 4006 4039 4010 3865
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-3
-2
-1
0
KNOTS


KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 WIND T+24
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
5
10
15
20
KNOTS


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 WIND T+24
OPER NOBS= 1692 1701 1695 1626 1601 1592 1574 1424
TRIAL NOBS= 1692 1700 1655 1627 1602 1589 1574 1422
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-4
-3
-2
-1
0


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 WIND T+24
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
5
10
15
20
KNOTS


KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 WIND T+24
OPER NOBS= 263 264 262 253 259 267 266 293
TRIAL NOBS= 262 264 262 252 259 269 266 293
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-4
-2
0
KNOTS

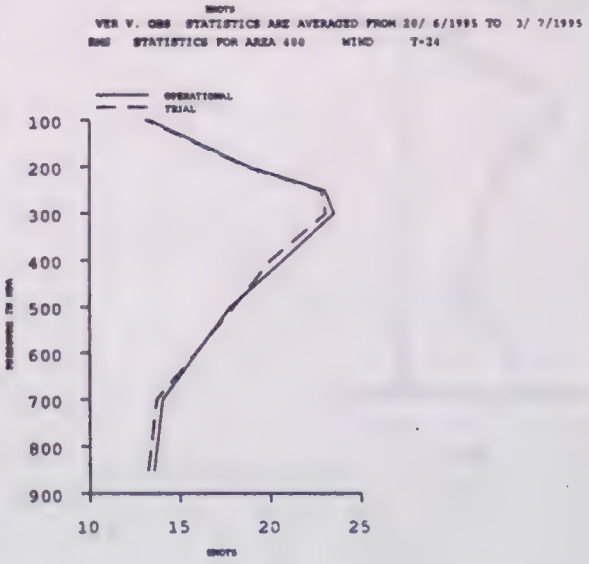
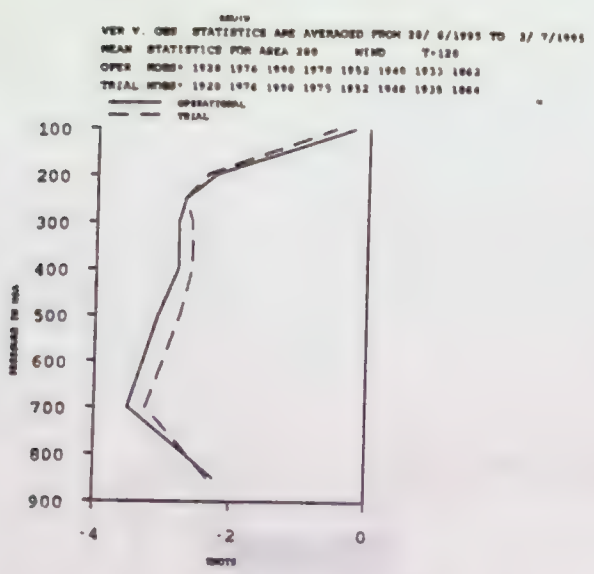
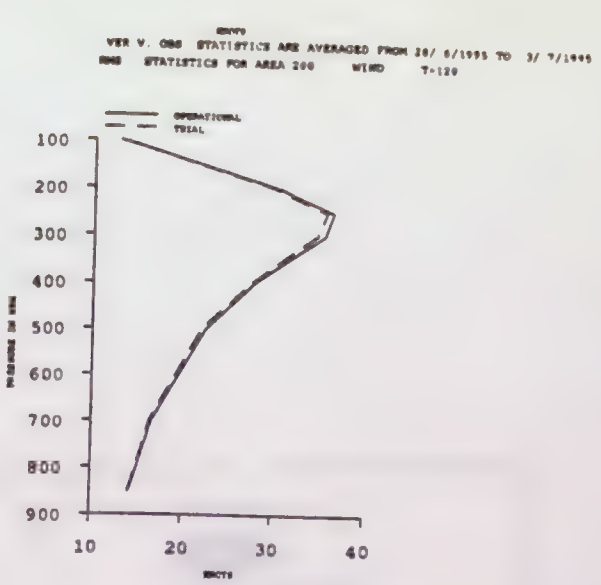
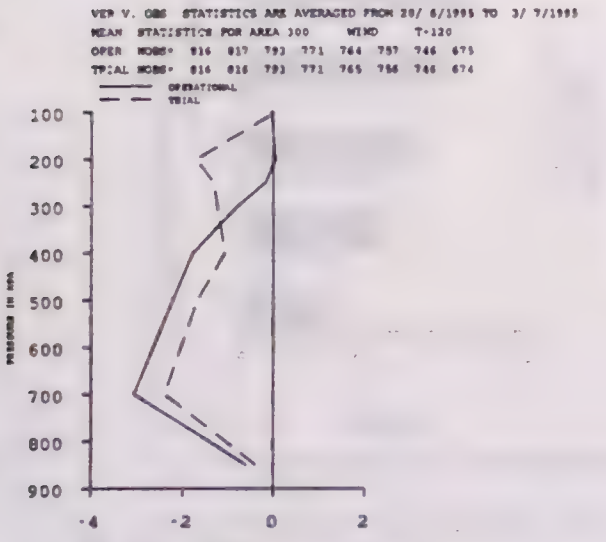
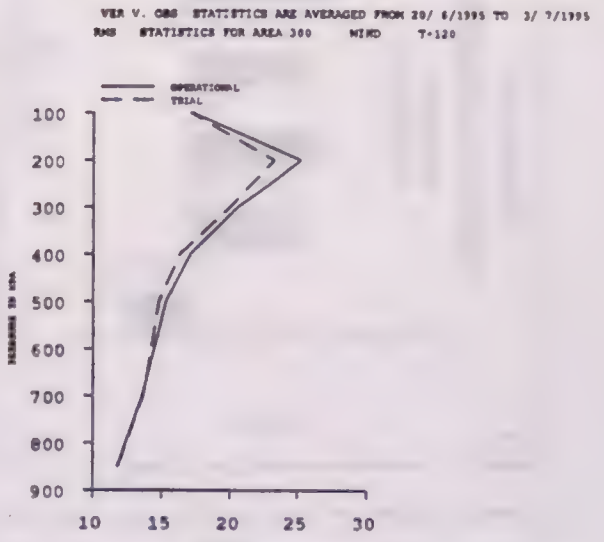

KNOTS
VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 WIND T+24
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
10
15
20
25
KNOTS

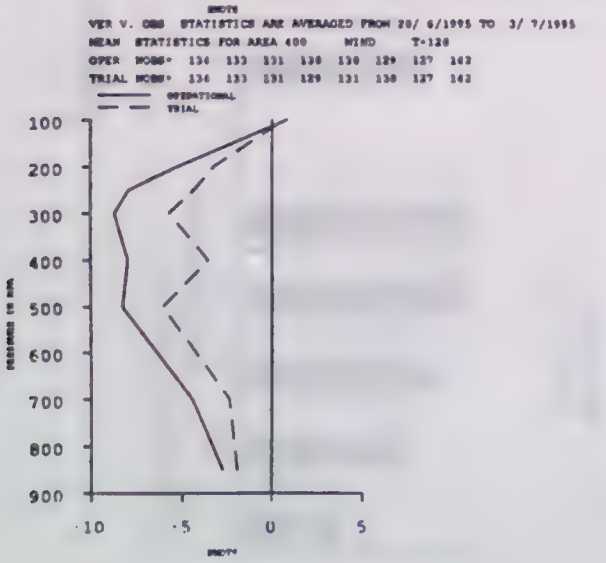
FIGURE 2.8


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 200 WIND T+120
OPER MOBS* 1920 1976 1990 1970 1952 1940 1933 1963
TRIAL MOBS* 1920 1976 1990 1975 1952 1940 1935 1964
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-4
-2
0
KNOTS


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 200 WIND T+120
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
10
20
30
40
KNOTS


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 300 WIND T+120
OPER MOBS* 816 817 793 771 764 757 746 675
TRIAL MOBS* 816 816 793 771 765 756 746 674
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-4
-2
0
2
KNOTS


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 300 WIND T+120
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
10
15
20
25
30
KNOTS


VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
MEAN STATISTICS FOR AREA 400 WIND T+120
OPER MOBS* 136 133 131 130 130 129 127 162
TRIAL MOBS* 136 133 131 129 131 130 127 162
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
-10
-5
0
5
KNOTS

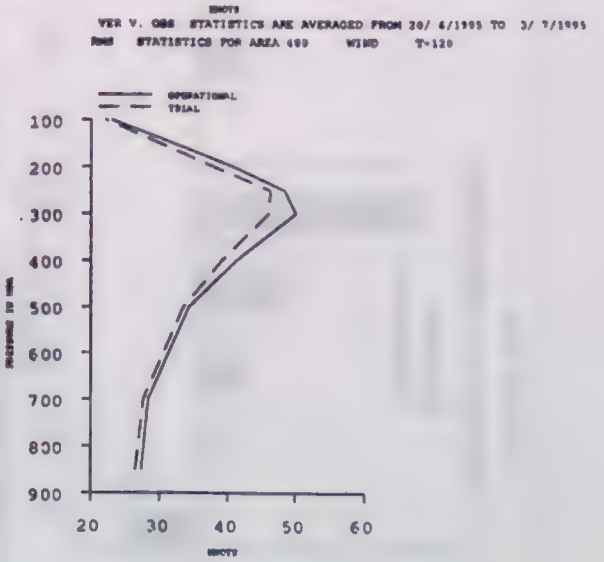

VER V. OBS STATISTICS ARE AVERAGED FROM 20/ 6/1995 TO 3/ 7/1995
RMS STATISTICS FOR AREA 400 WIND T+120
OPERATIONAL
TRIAL
100
200
300
400
500
600
700
800
900
20
30
40
50
60
KNOTS

FIGURE 2.9

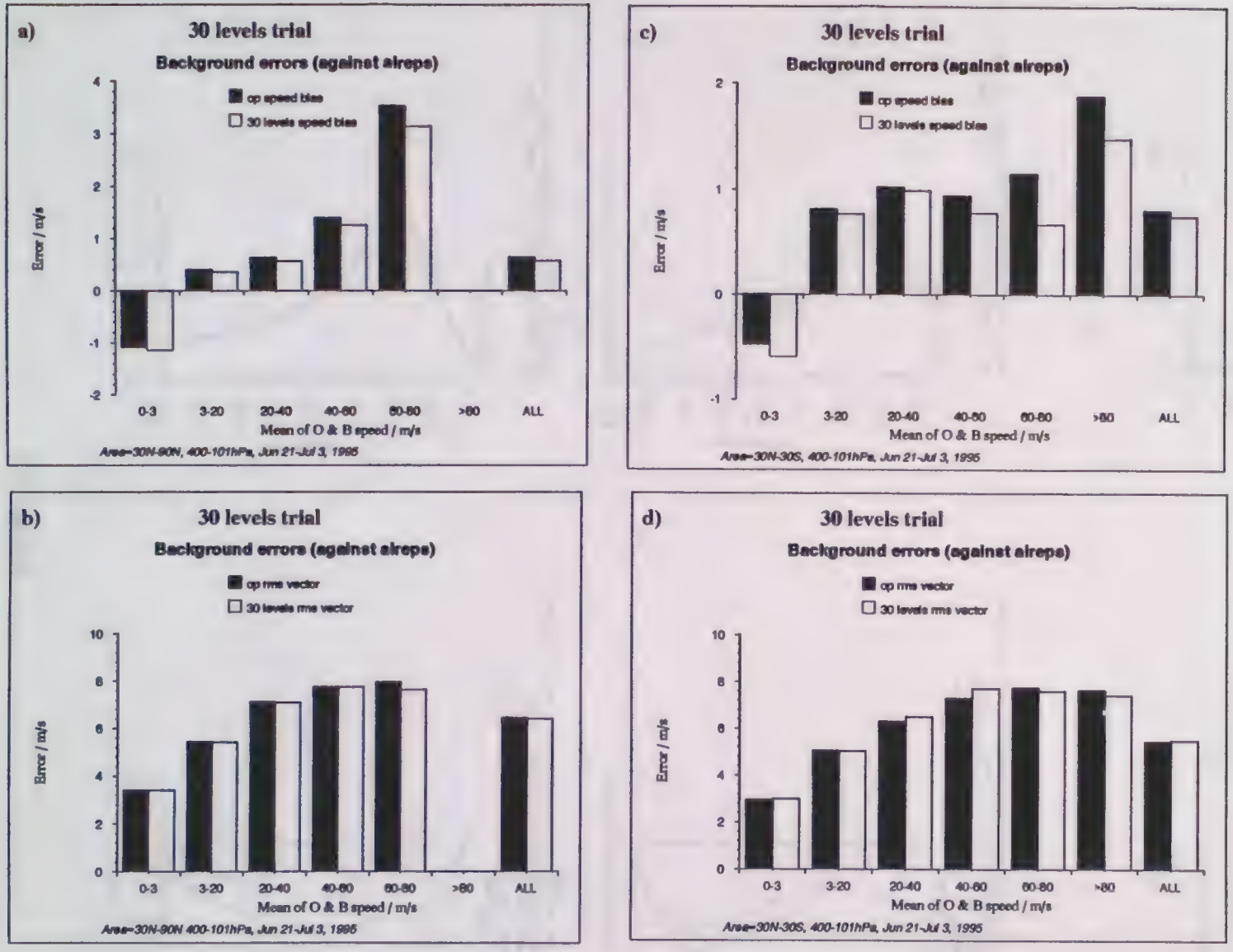

a)
30 levels trial
Background errors (against airep)
op speed bias
30 levels speed bias
Error / m/s
Mean of O & B speed / m/s
0-3
3-20
20-40
40-60
60-80
>80
ALL
Area=30N-90N, 400-101hPa, Jun 21-Jul 3, 1995
c)
30 levels trial
Background errors (against airep)
op speed bias
30 levels speed bias
Error / m/s
Mean of O & B speed / m/s
Area=30N-30S, 400-101hPa, Jun 21-Jul 3, 1995
b)
30 levels trial
Background errors (against airep)
op rms vector
30 levels rms vector
Error / m/s
Mean of O & B speed / m/s
Area=30N-90N 400-101hPa, Jun 21-Jul 3, 1995
d)
30 levels trial
Background errors (against airep)
op rms vector
30 levels rms vector
Error / m/s
Mean of O & B speed / m/s
Area=30N-30S, 400-101hPa, Jun 21-Jul 3, 1995

Figure 2.10

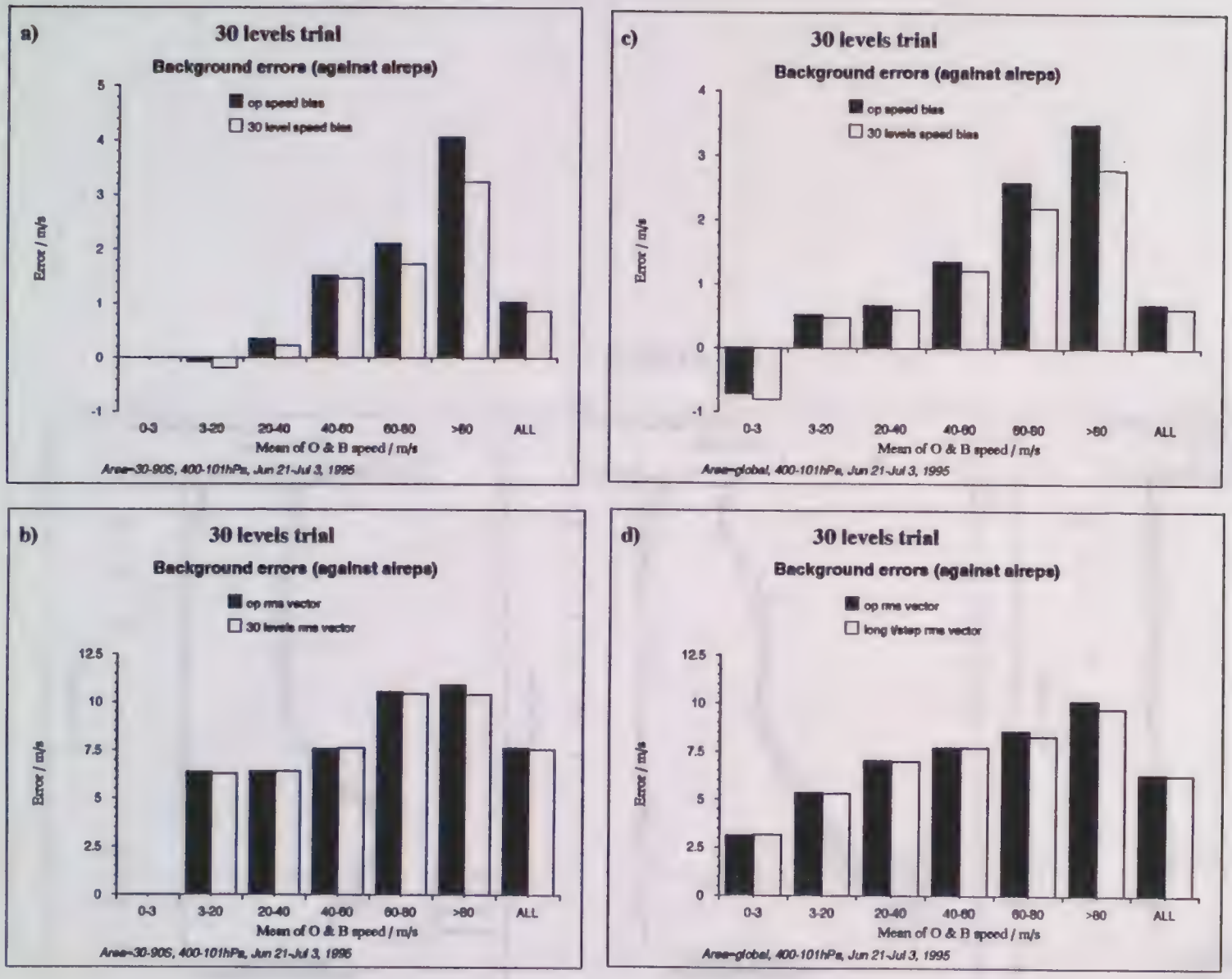

a)
30 levels trial
Background errors (against aireps)
op speed bias
30 level speed bias
Error / m/s
0-3
3-20
20-40
40-60
60-80
>80
ALL
Mean of O & B speed / m/s
Area=30-90S, 400-101hPa, Jun 21-Jul 3, 1995
c)
30 levels trial
Background errors (against aireps)
op speed bias
30 levels speed bias
Error / m/s
Mean of O & B speed / m/s
Area=global, 400-101hPa, Jun 21-Jul 3, 1995
b)
30 levels trial
Background errors (against aireps)
op rms vector
30 levels rms vector
Error / m/s
Mean of O & B speed / m/s
Area=30-90S, 400-101hPa, Jun 21-Jul 3, 1995
d)
30 levels trial
Background errors (against aireps)
op rms vector
long tstep rms vector
Error / m/s
Mean of O & B speed / m/s
Area=global, 400-101hPa, Jun 21-Jul 3, 1995

Figure 2.11

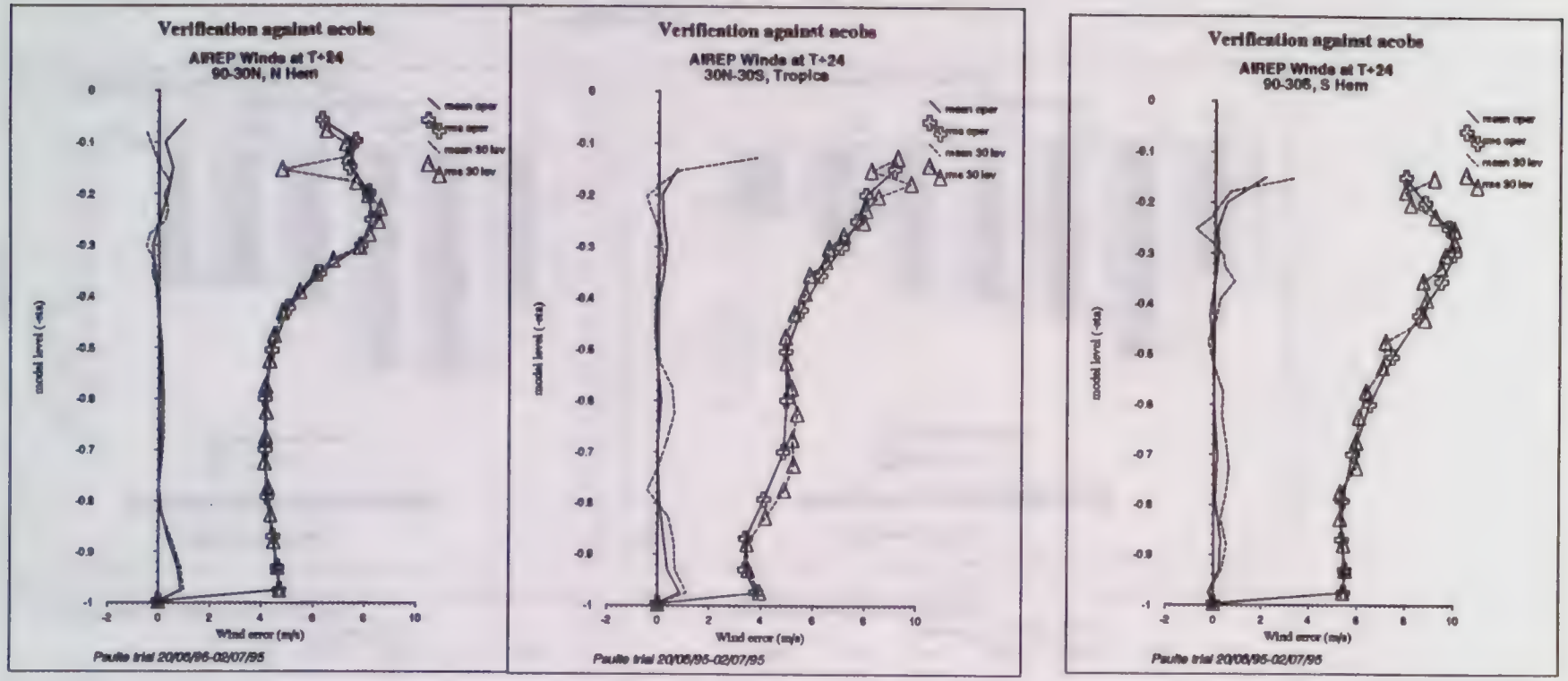
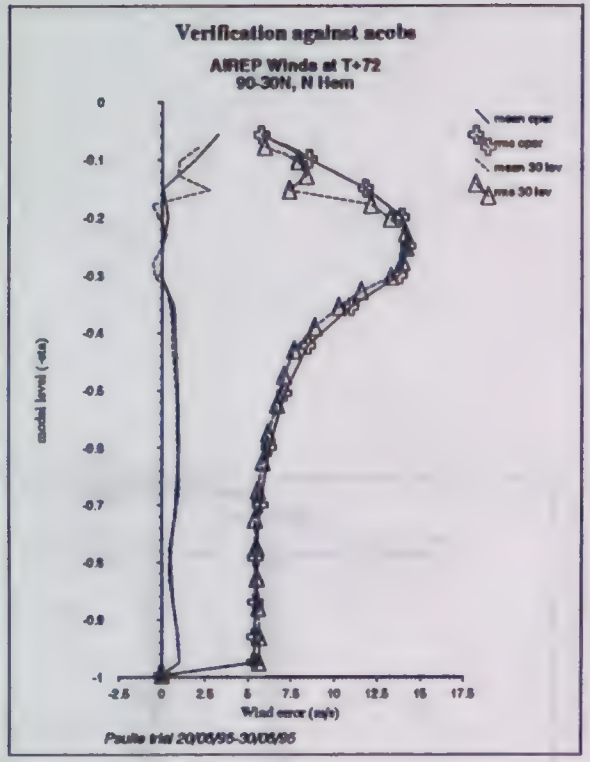
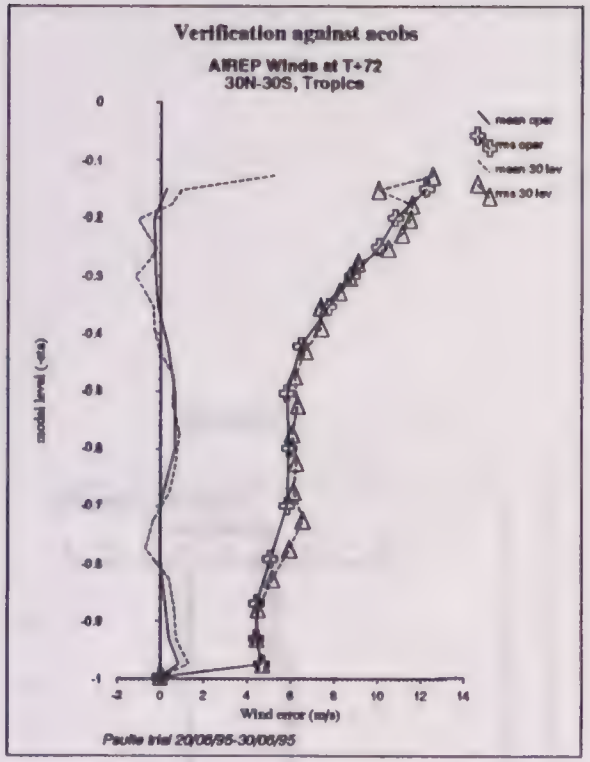

Verification against ecobs
AIREP Winds at T+24
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95
Verification against ecobs
AIREP Winds at T+24
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95
Verification against ecobs
AIREP Winds at T+24
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95

FIGURE 2.12


Verification against acobs
AIREP Winds at T+72
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulie trial 20/06/95-30/06/95


Verification against acobs
AIREP Winds at T+72
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulie trial 20/06/95-30/06/95

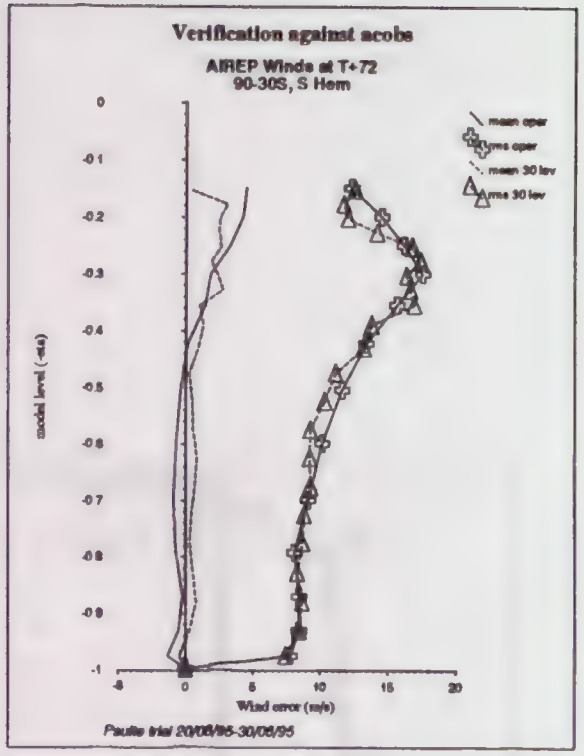

Verification against acobs
AIREP Winds at T+72
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulie trial 20/06/95-30/06/95

FIGURE 2.13

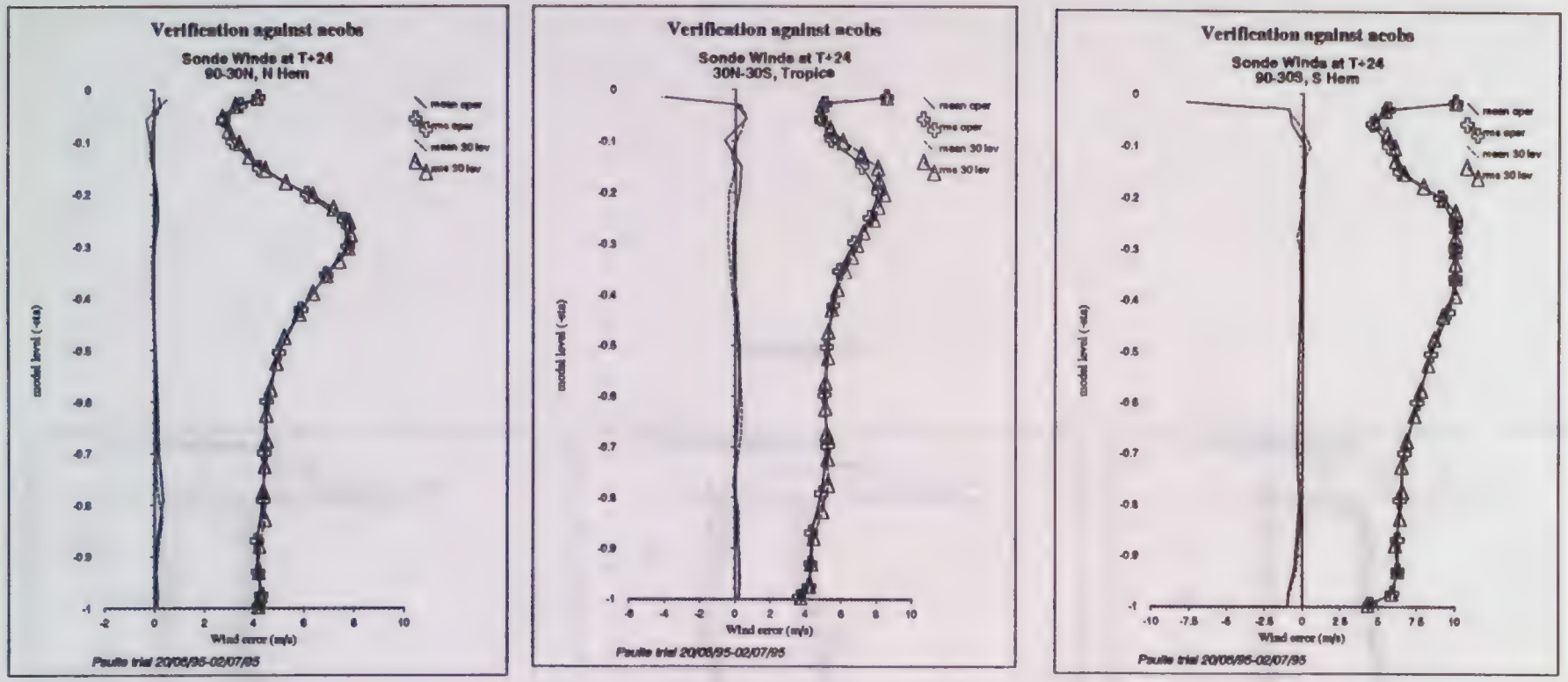
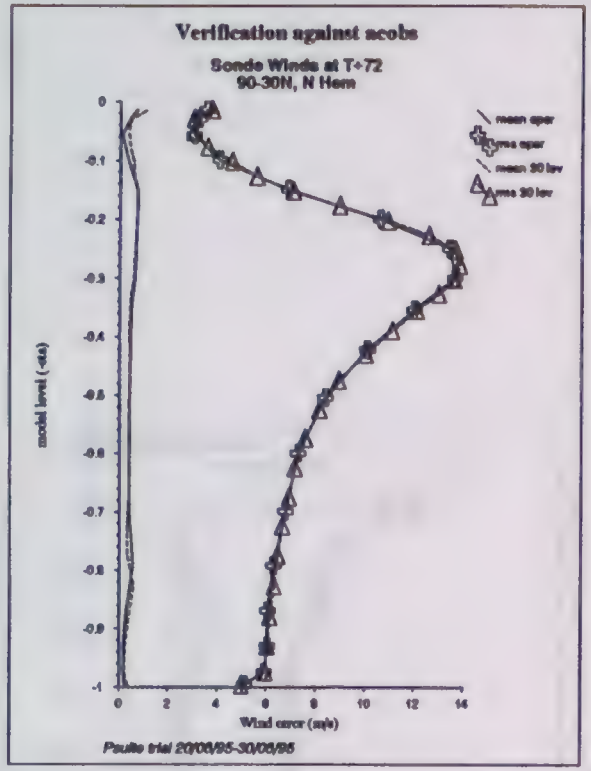
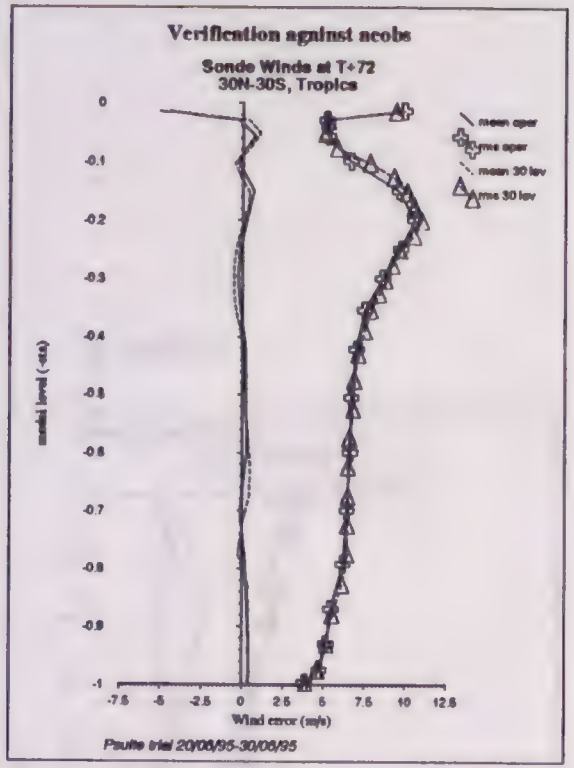

Verification against acobs
Sonde Winds at T+24
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95
Verification against acobs
Sonde Winds at T+24
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95
Verification against acobs
Sonde Winds at T+24
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Wind error (m/s)
Paulte trial 20/06/95-02/07/95

FIGURE 2.14


Verification against ecobs
Sonde Winds at T+72
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (-sig)
Wind error (m/s)
Paulle trial 20/05/95-30/06/95


Verification against ecobs
Sonde Winds at T+72
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (-sig)
Wind error (m/s)
Paulle trial 20/05/95-30/06/95

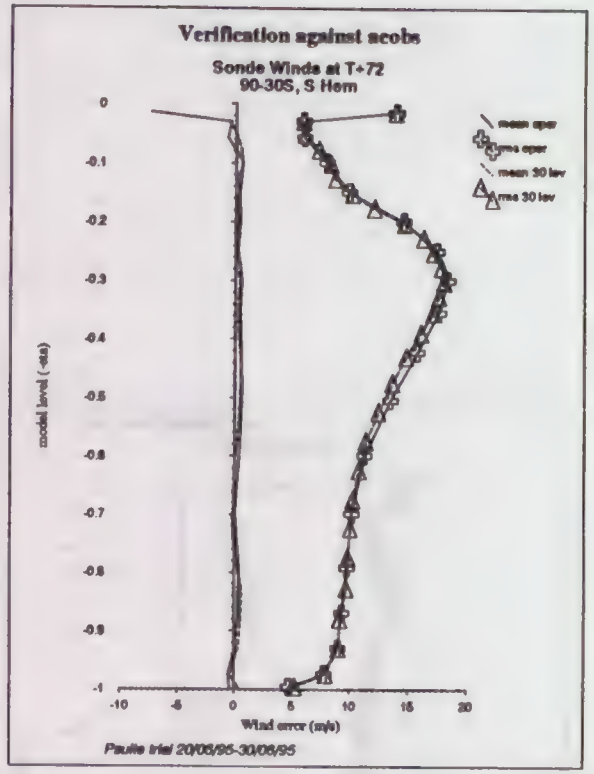

Verification against ecobs
Sonde Winds at T+72
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (-sig)
Wind error (m/s)
Paulle trial 20/05/95-30/06/95

FIGURE 2.15

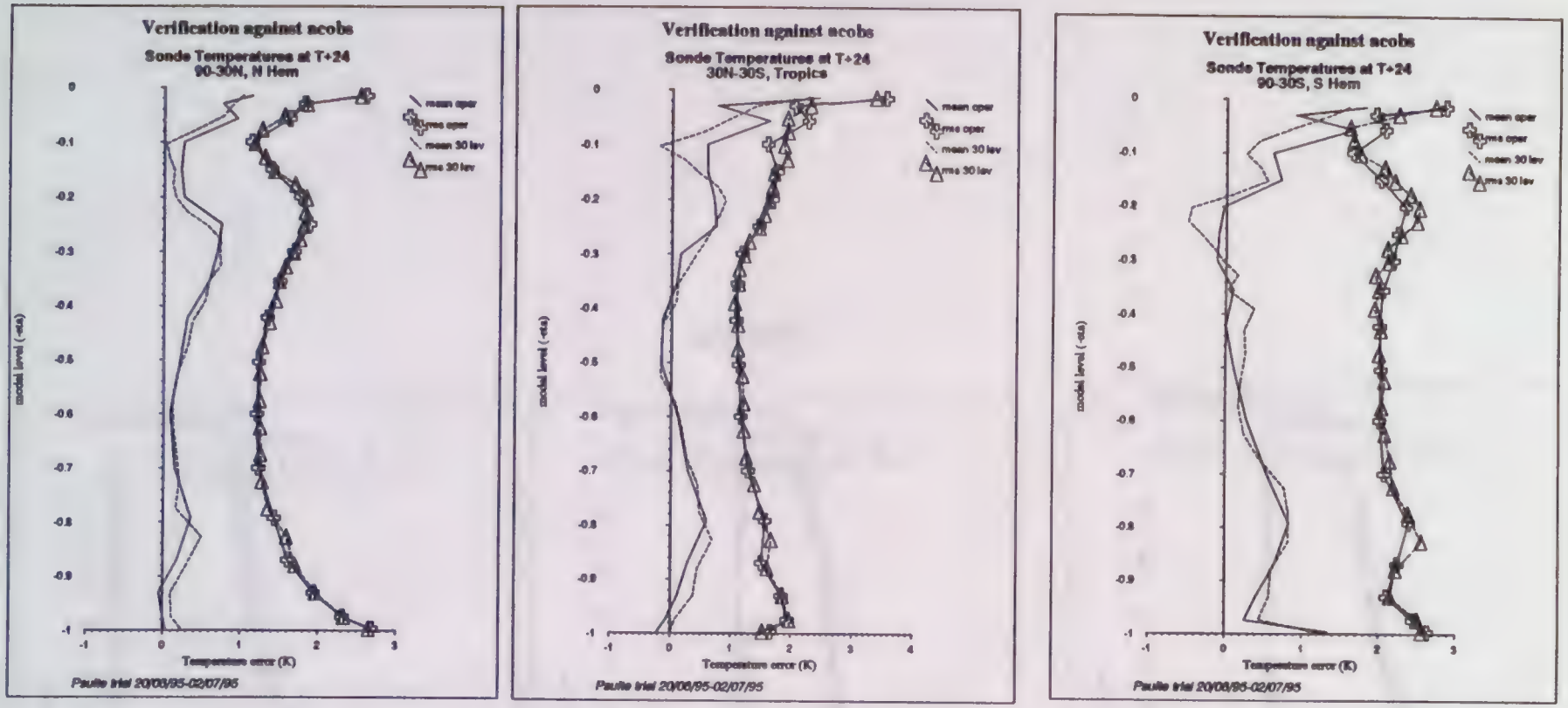

Verification against acobs
Sonde Temperatures at T+24
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
modal level (-eta)
Temperature error (K)
Paulie trial 20/06/95-02/07/95
Verification against acobs
Sonde Temperatures at T+24
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
modal level (-eta)
Temperature error (K)
Paulie trial 20/06/95-02/07/95
Verification against acobs
Sonde Temperatures at T+24
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
modal level (-eta)
Temperature error (K)
Paulie trial 20/06/95-02/07/95

FIGURE 2.16

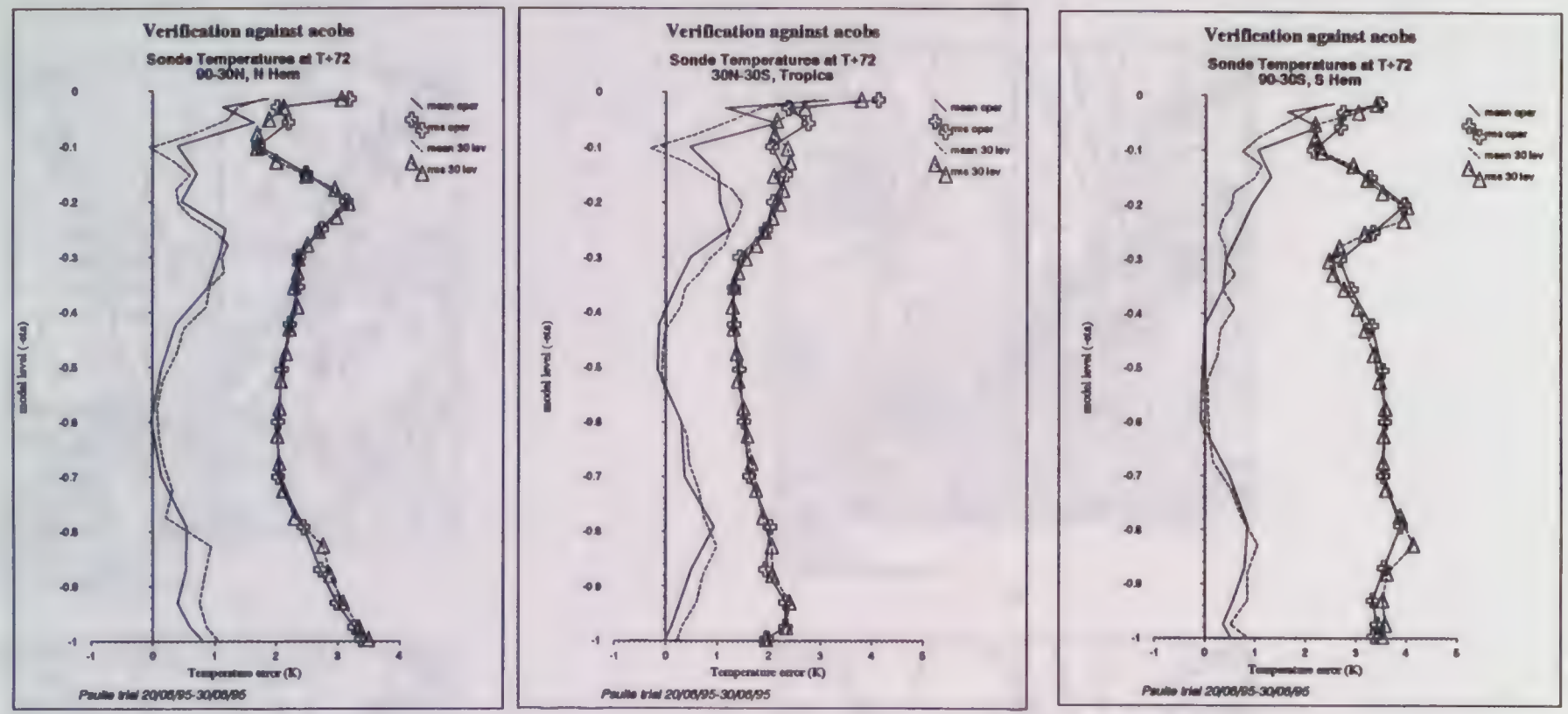
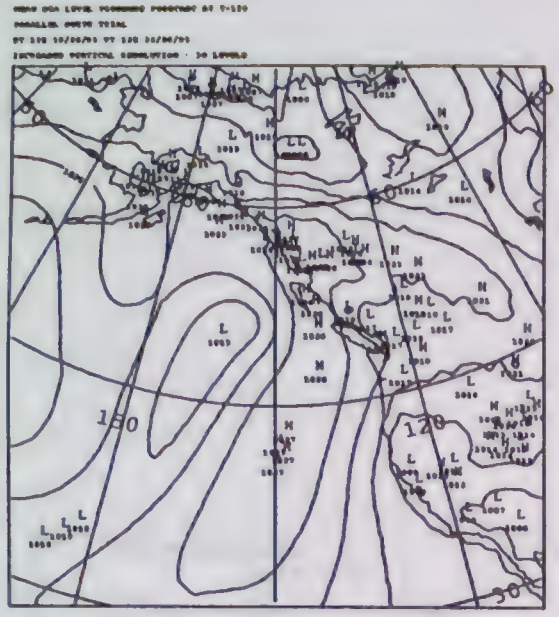
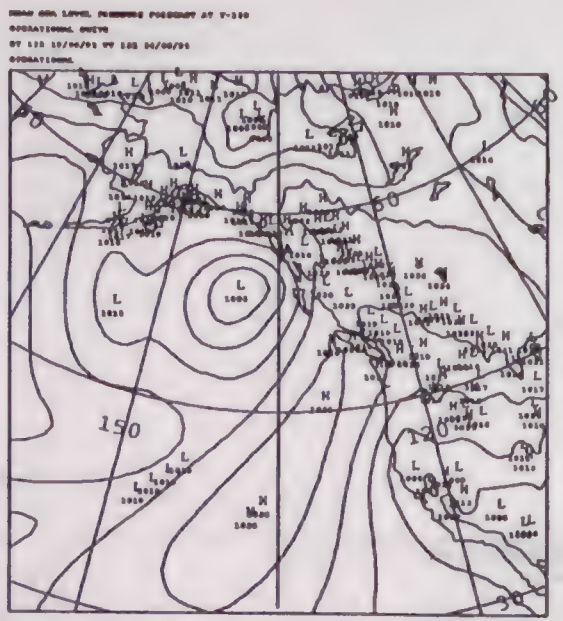

Verification against acobs
Sonde Temperatures at T+72
90-30N, N Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Temperature error (K)
Paulo trial 20/06/95-30/06/95
Verification against acobs
Sonde Temperatures at T+72
30N-30S, Tropics
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Temperature error (K)
Paulo trial 20/06/95-30/06/95
Verification against acobs
Sonde Temperatures at T+72
90-30S, S Hem
mean oper
rms oper
mean 30 lev
rms 30 lev
model level (~eta)
Temperature error (K)
Paulo trial 20/06/95-30/06/95

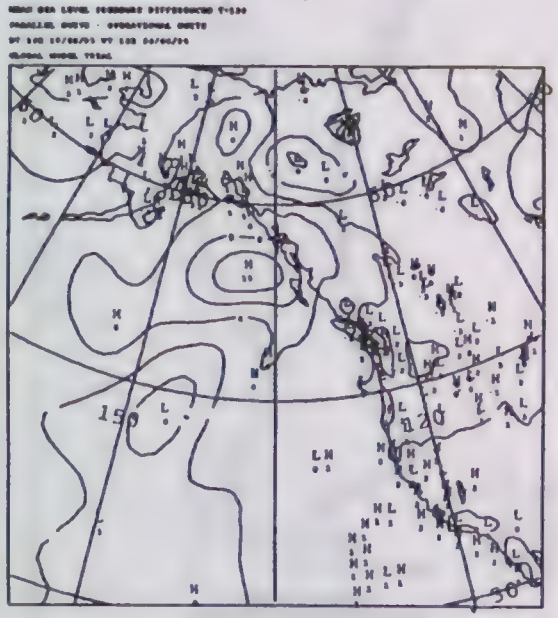
FIGURE 2.17



a



b



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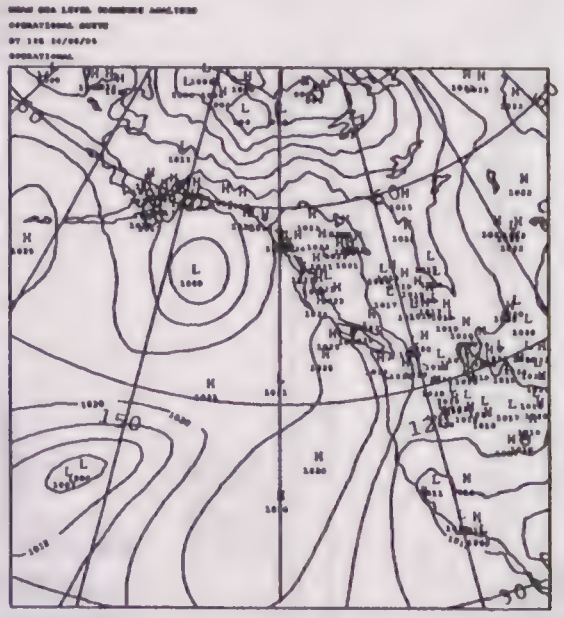
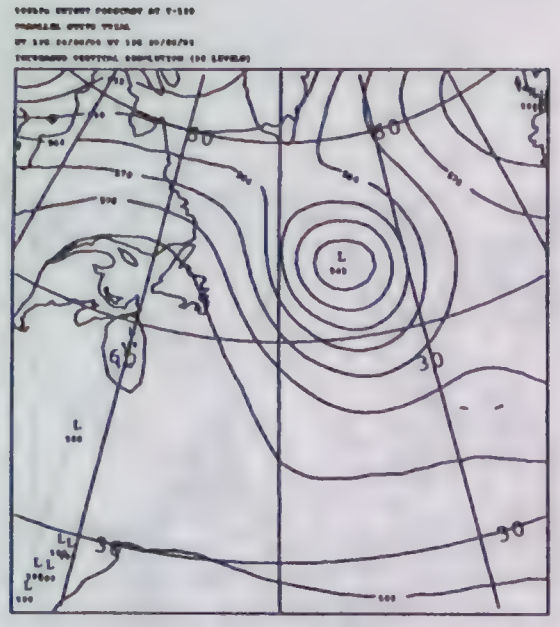
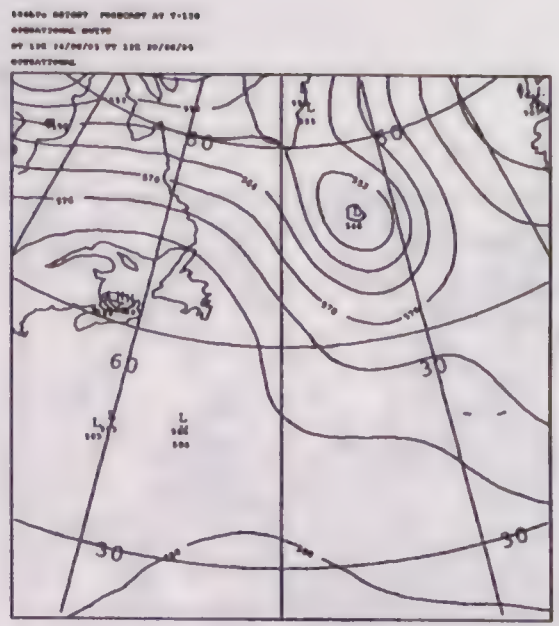


d

Figure 3.1



a



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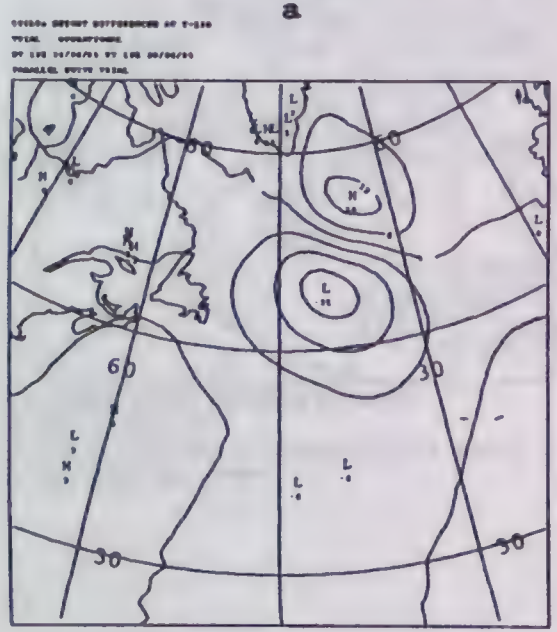

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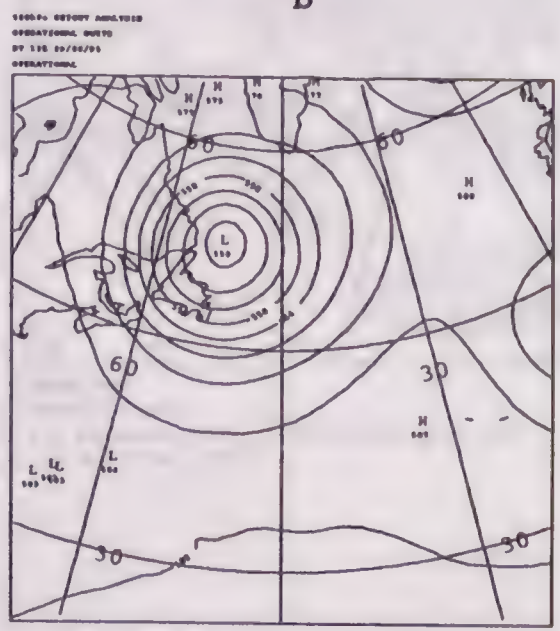


d

Figure 3.2

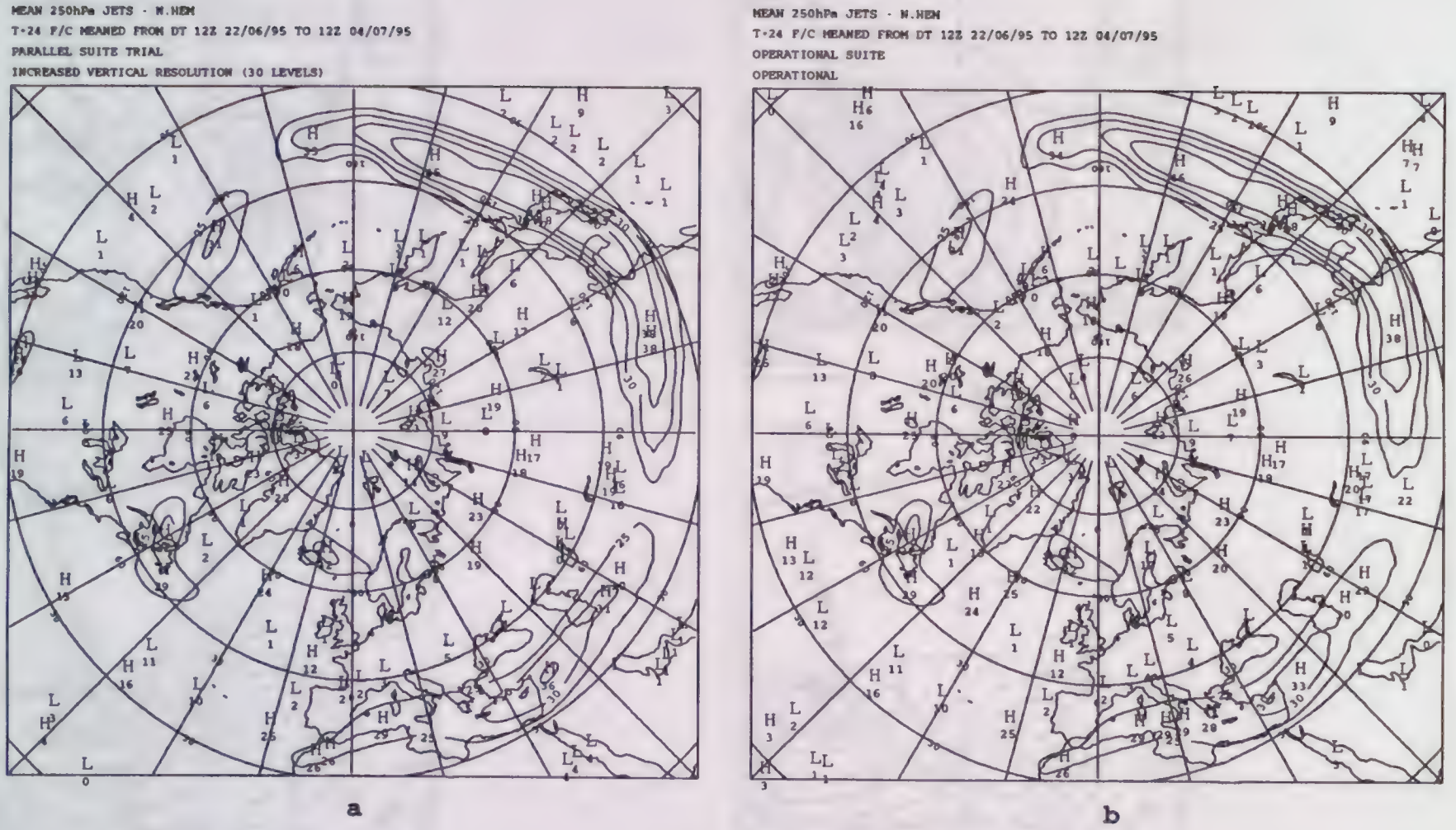

MEAN 250hPa JETS - N.HEM
T+24 F/C MEANED FROM DT 12Z 22/06/95 TO 12Z 04/07/95
PARALLEL SUITE TRIAL
INCREASED VERTICAL RESOLUTION (30 LEVELS)
a
MEAN 250hPa JETS - N.HEM
T+24 F/C MEANED FROM DT 12Z 22/06/95 TO 12Z 04/07/95
OPERATIONAL SUITE
OPERATIONAL
b

Figure 3.3

INCREASED LOW CLOUD T+72 GLOBAL
PARALLEL SUITE TRIAL - OPERATIONAL
T+72 FORECAST MEANED FROM 12Z 24/06/95 TO 12Z 06/07/95
TRIAL OF INCREASED VERTICAL RESOLUTION (30 LEVELS)

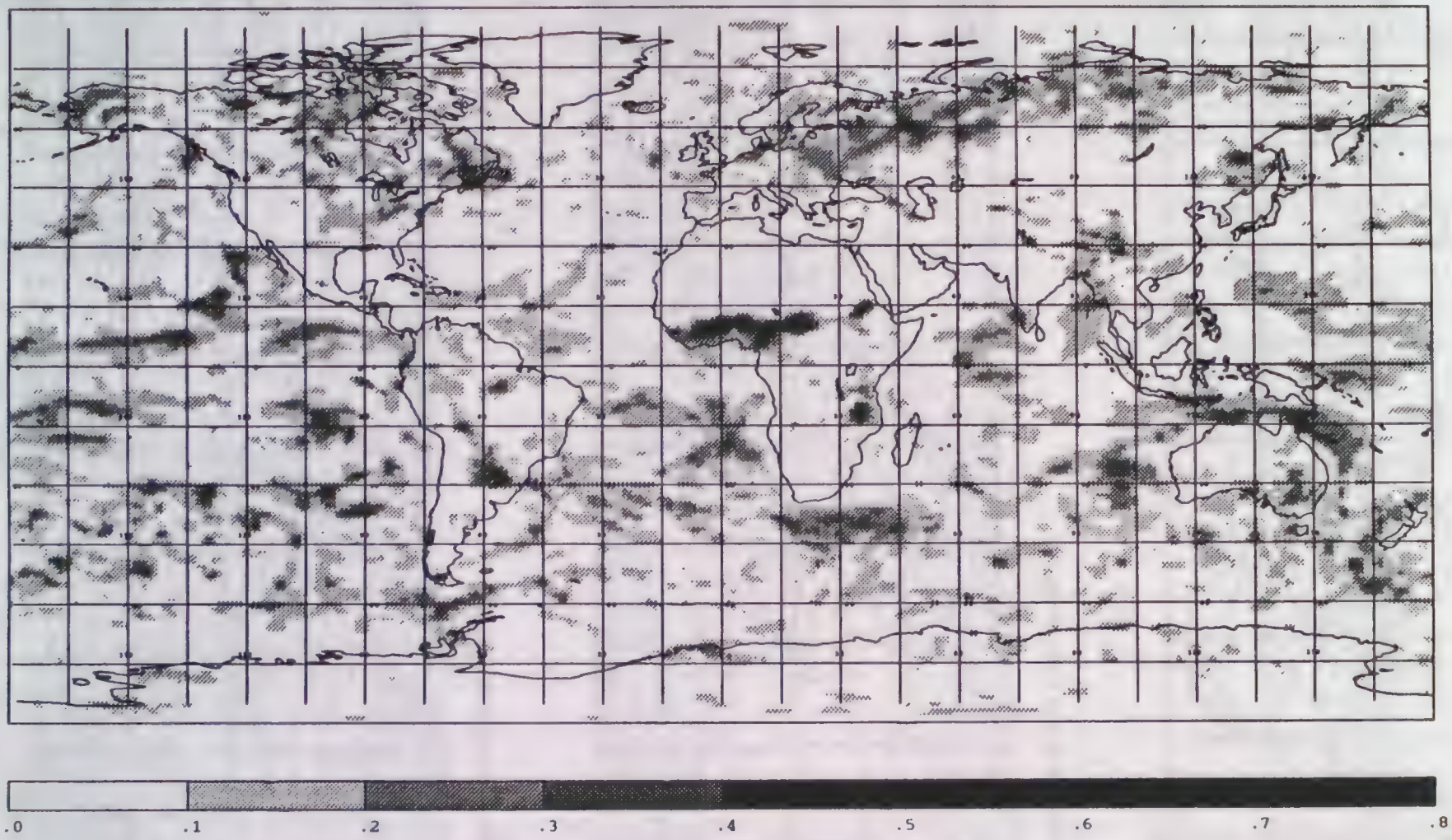
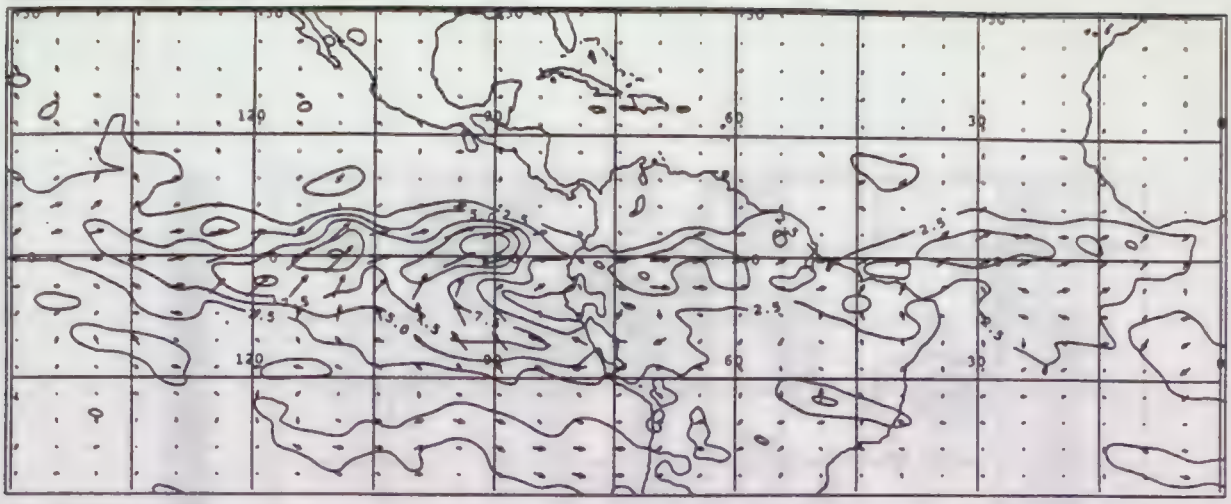


Figure 3.4

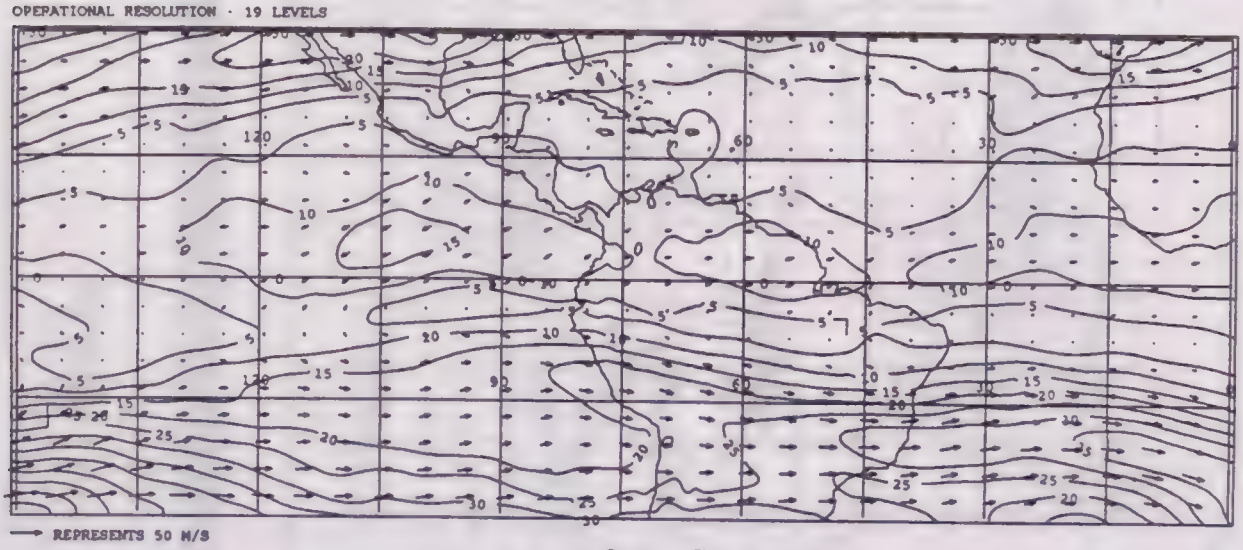
MEAN 250hPa WIND DIFFERENCES
T+24 F/C MEANED FROM 12Z 22/06/95 TO 12Z 04/07/95
TRIAL - OPERATIONAL
INCREASED VERTICAL RESOLUTION - 30 LEVELS



REPRESENTS 10 M/S

a

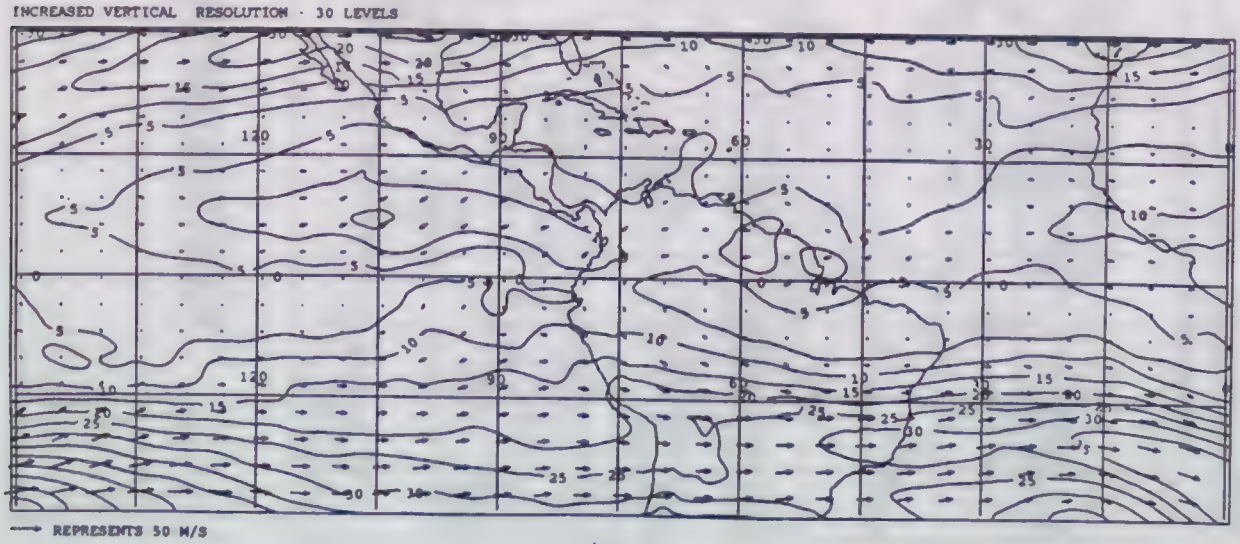
MEAN 250hPa WIND
T+24 F/C MEANED FROM 12Z 22/06/95 TO 12Z 04/07/95
OPERATIONAL
OPERATIONAL RESOLUTION - 19 LEVELS



REPRESENTS 50 M/S

b

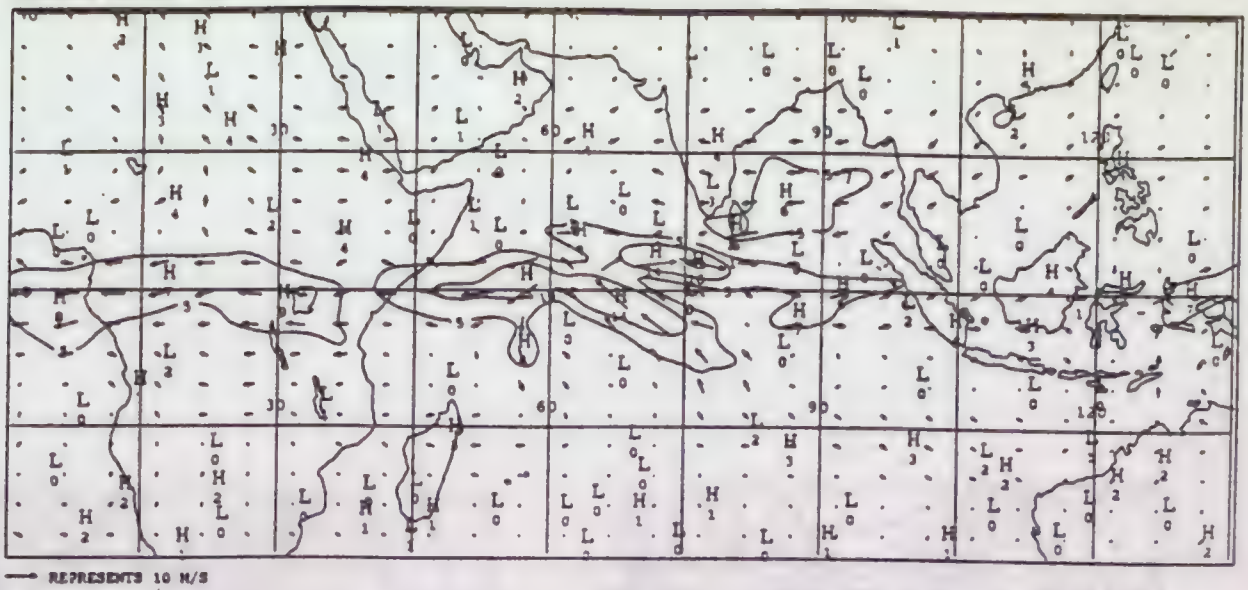
MEAN 250hPa WIND
T+24 F/C MEANED FROM 12Z 22/06/95 TO 12Z 04/07/95
TRIAL
INCREASED VERTICAL RESOLUTION - 30 LEVELS



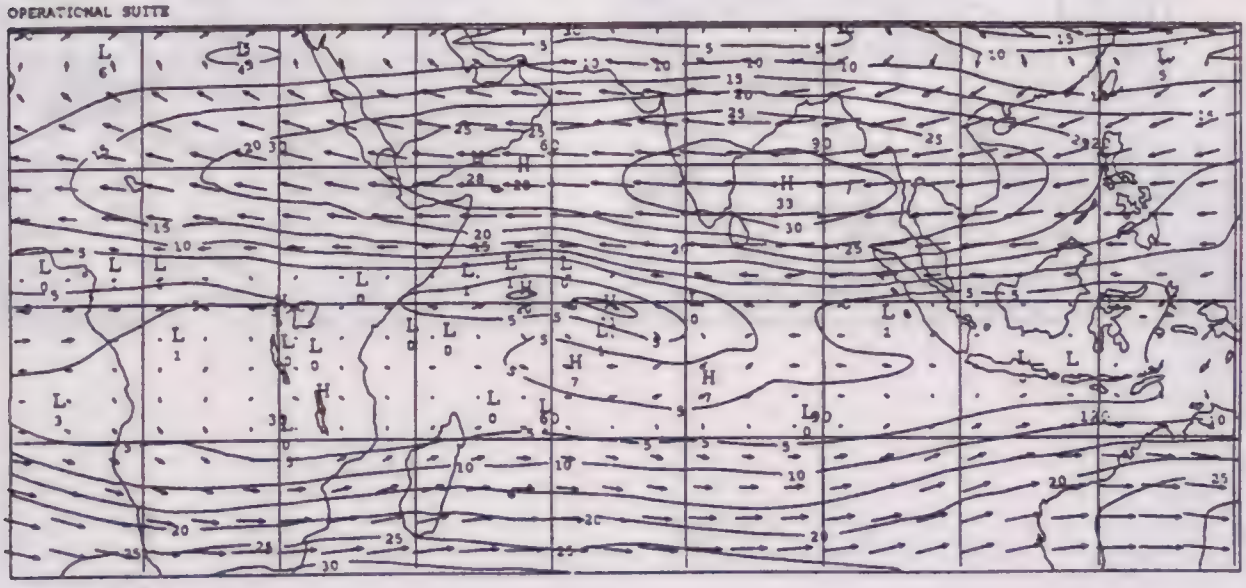
REPRESENTS 50 M/S

c

Figure 3.5



a



b

c

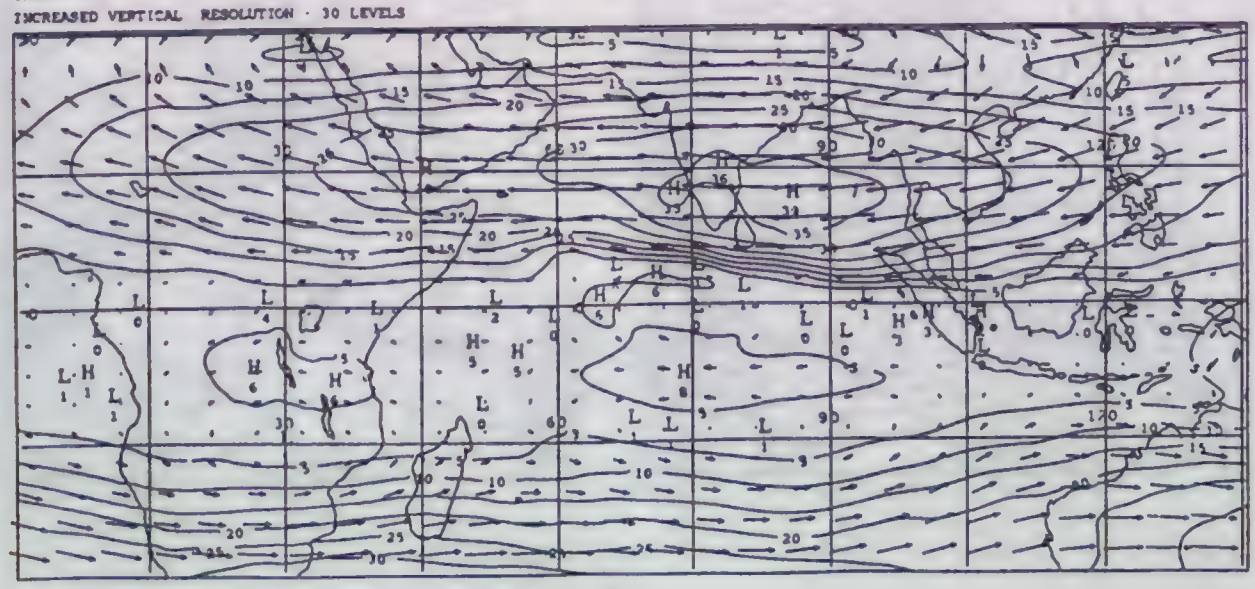
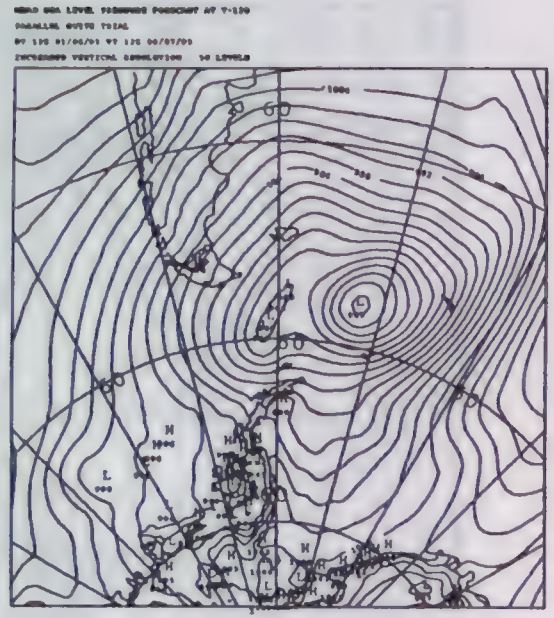
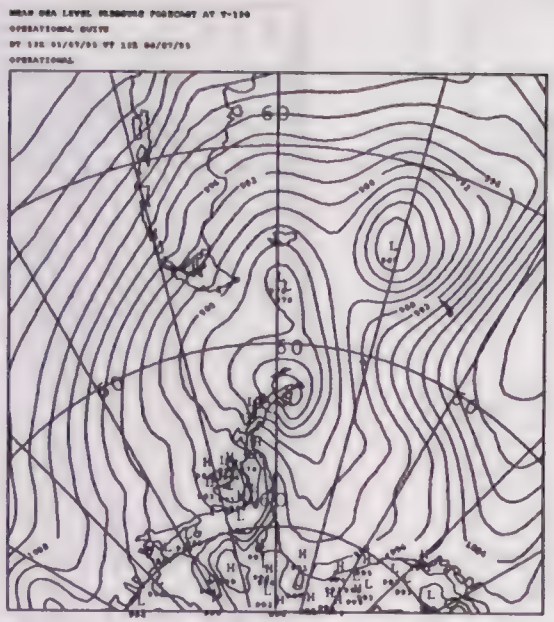


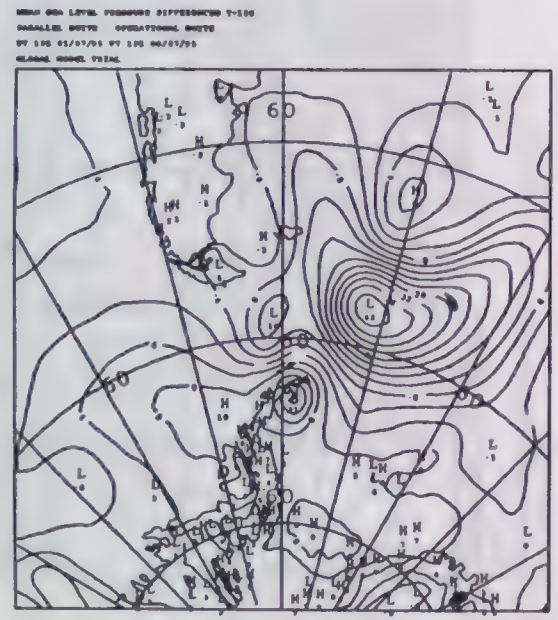
Figure 3.6



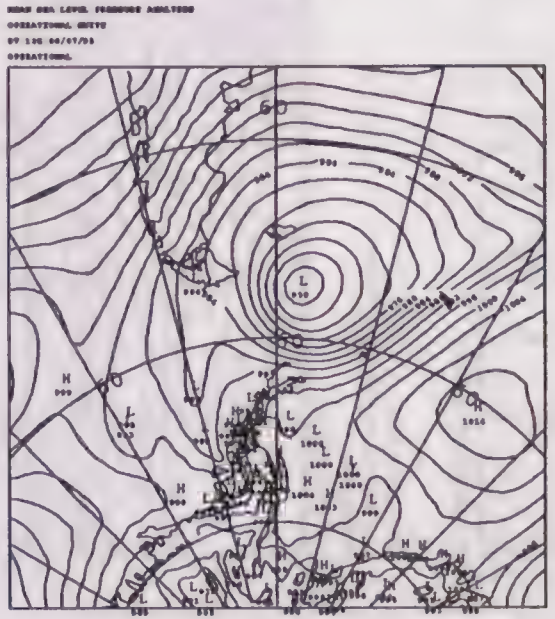
a



b

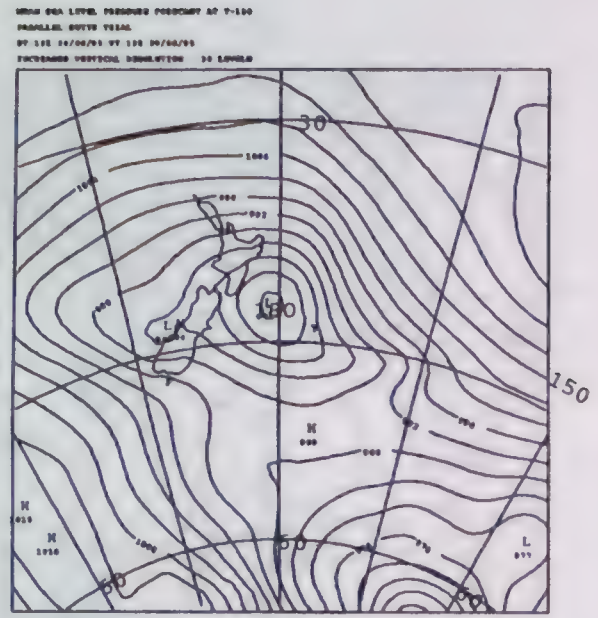


c



d

Figure 3.7



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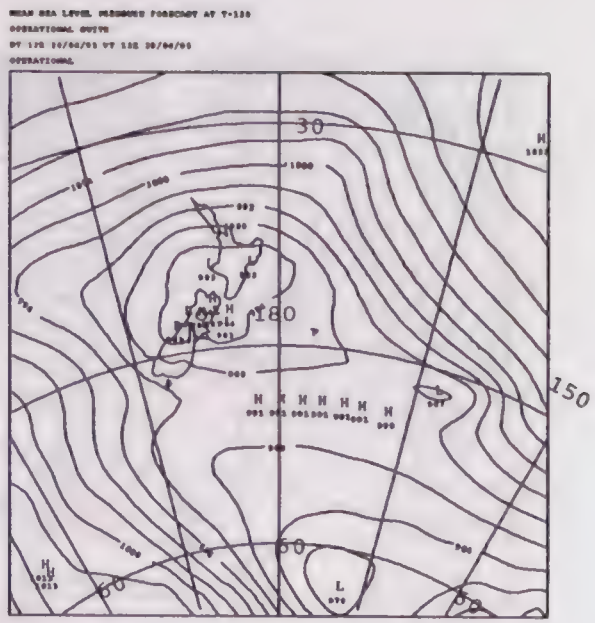

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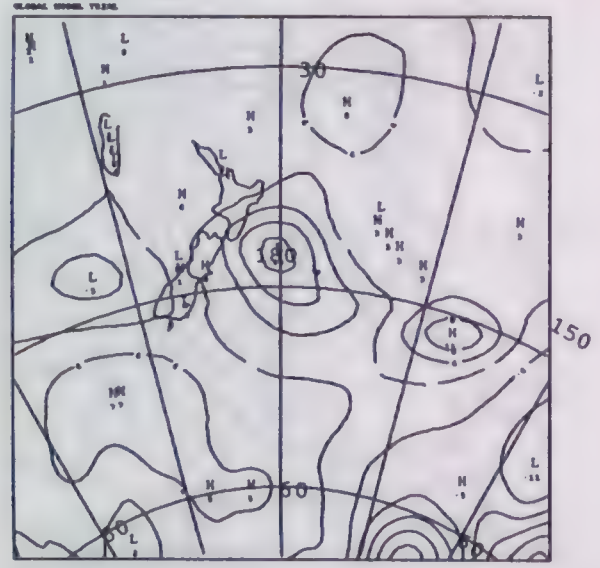

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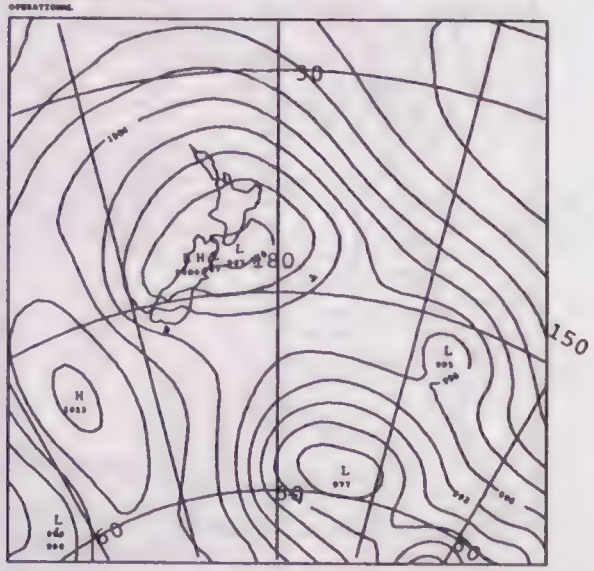
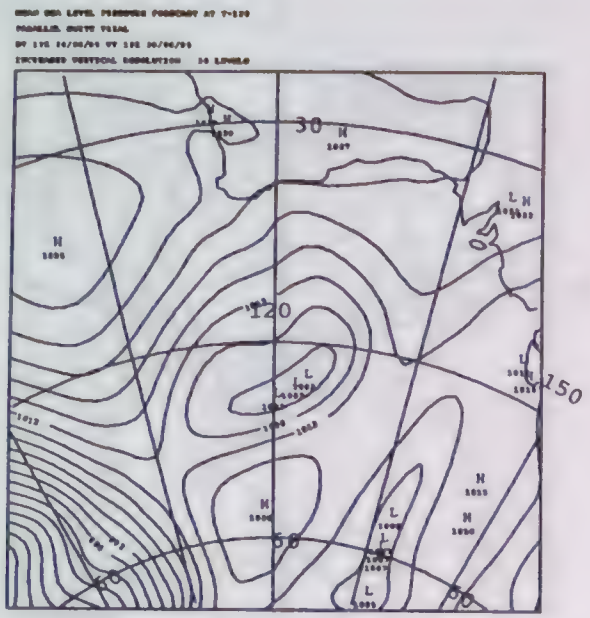


d

Figure 3.8



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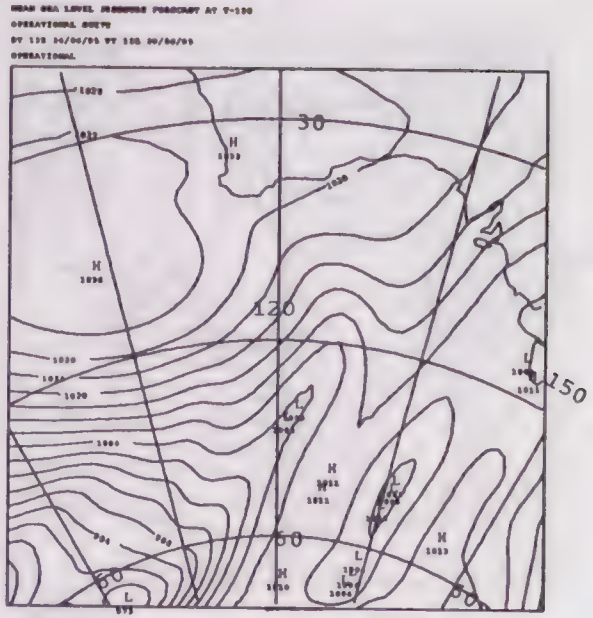

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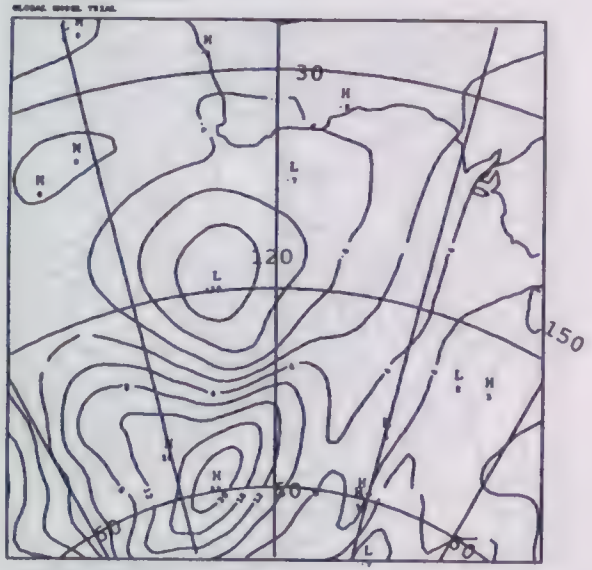

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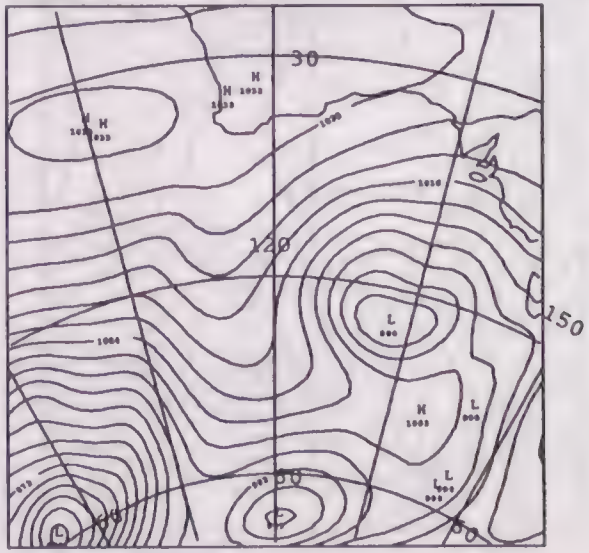

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Figure 3.9

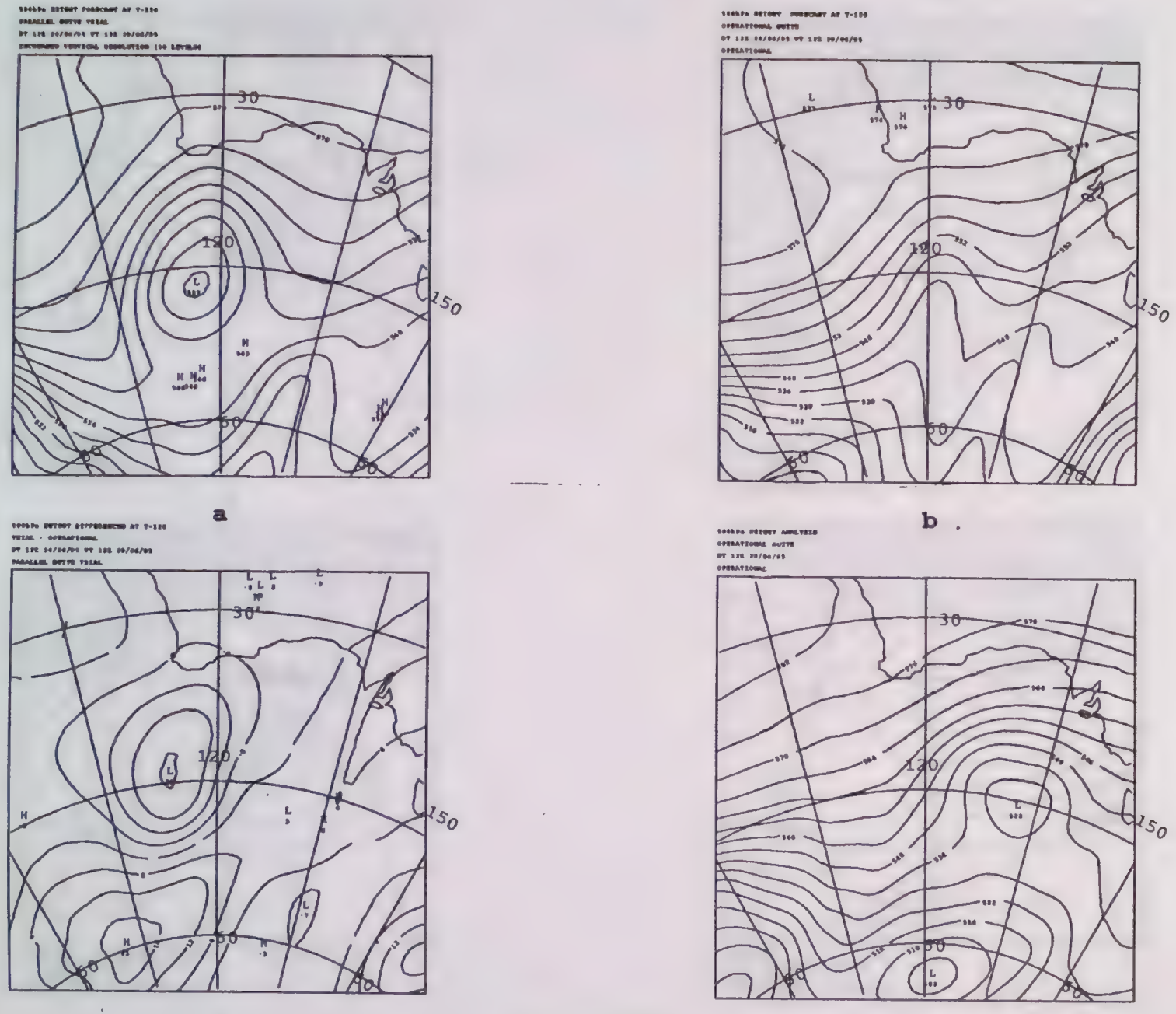
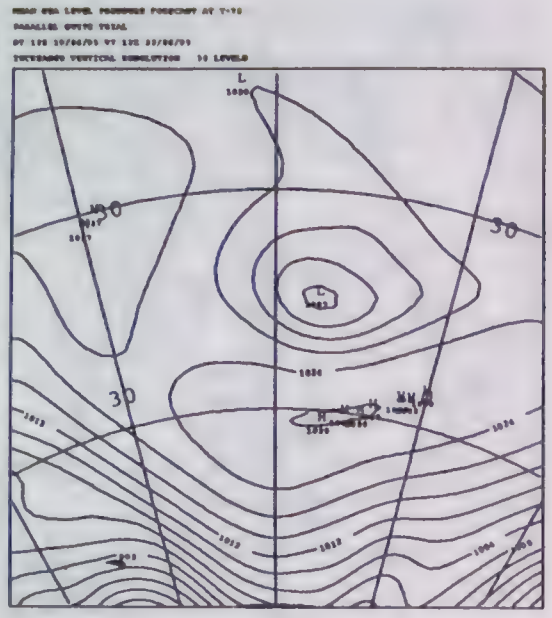
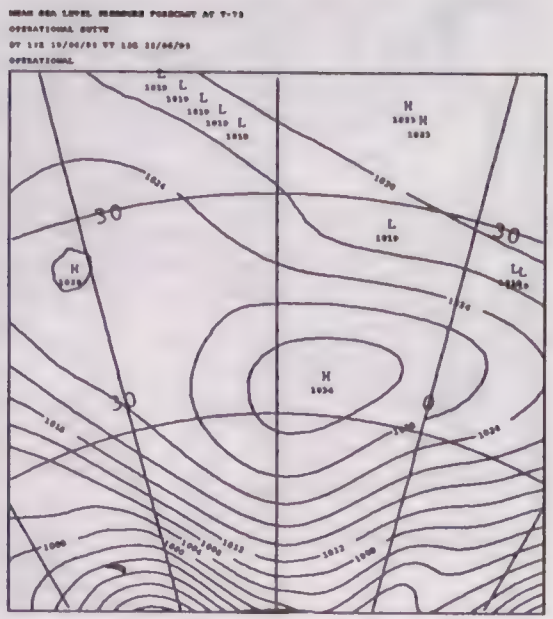


Figure 3.10



a



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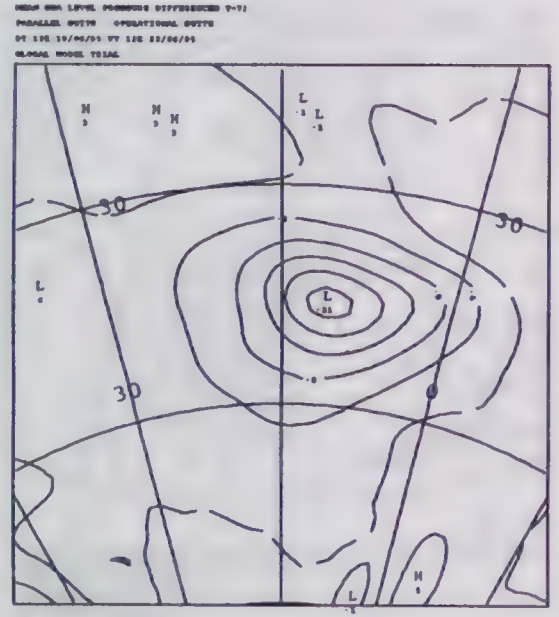

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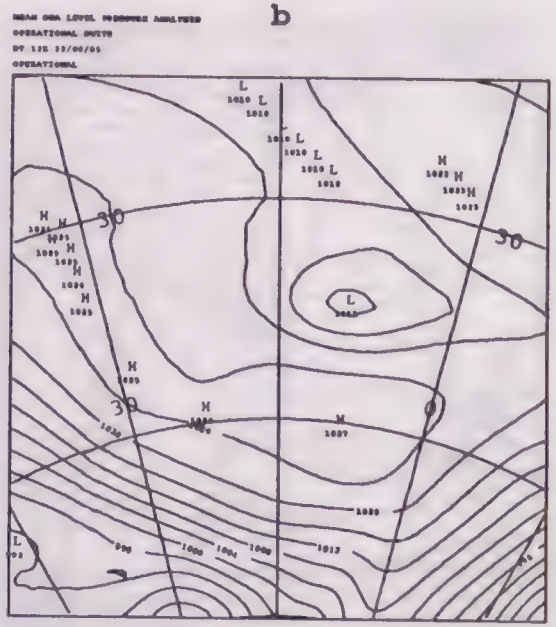
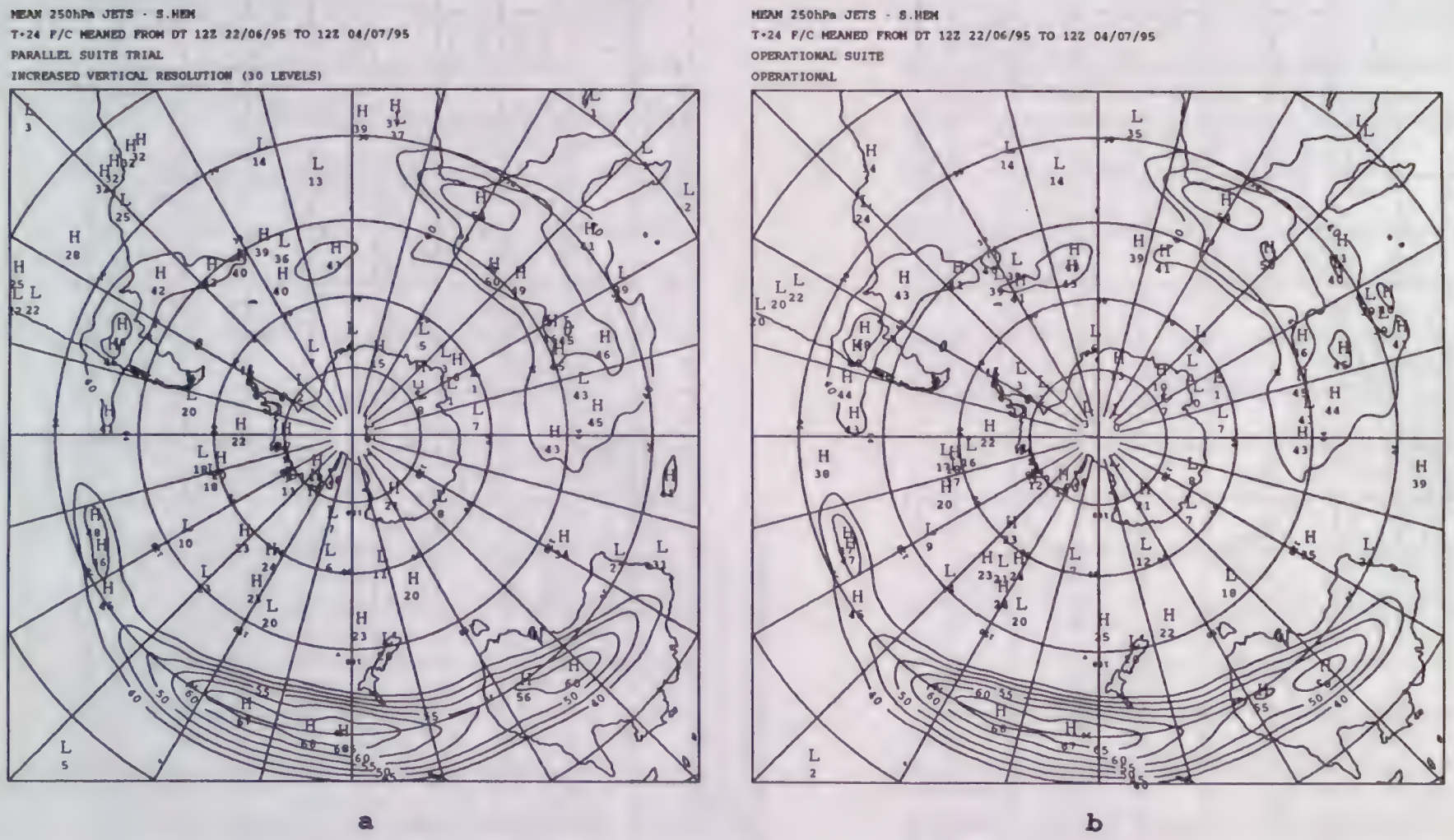


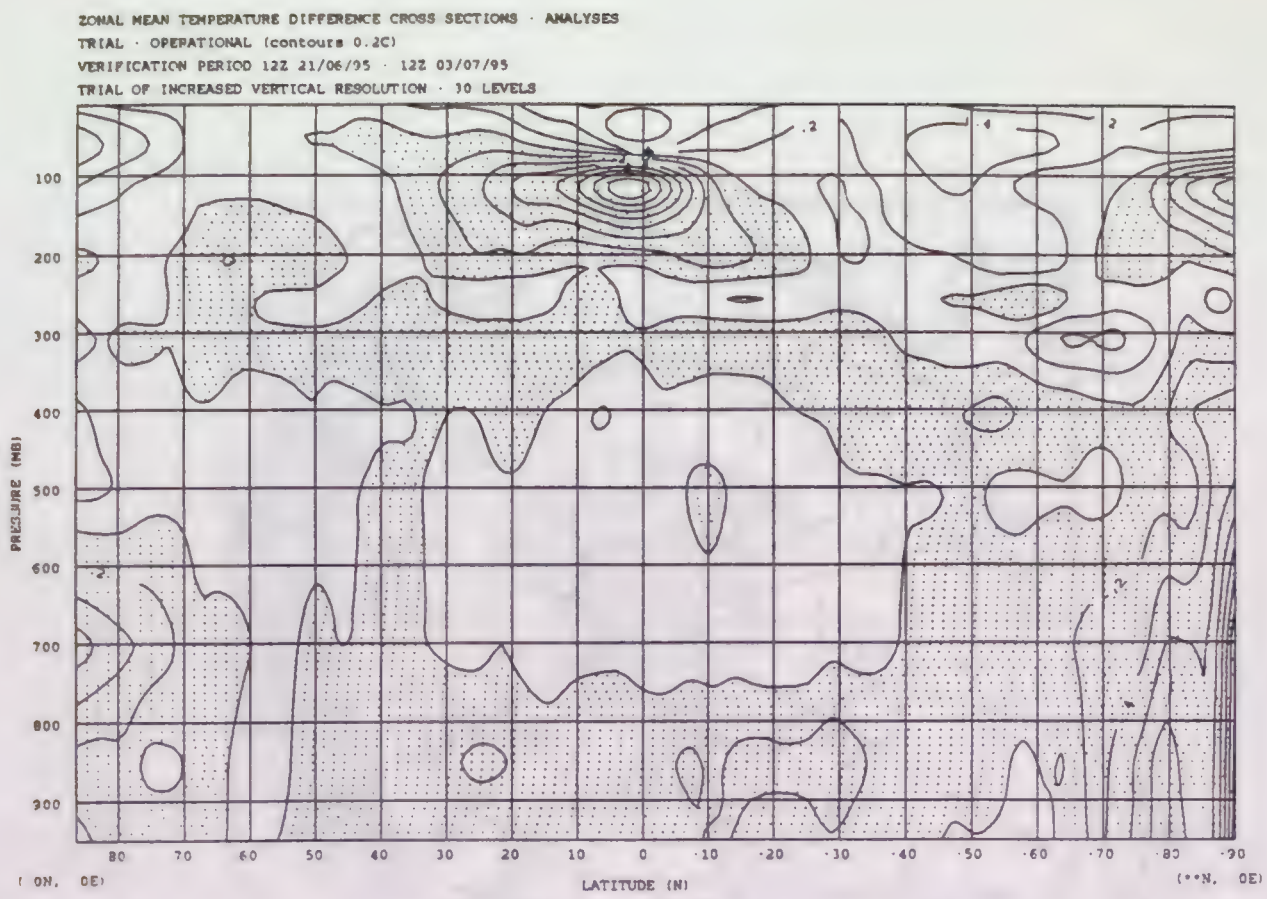
d

Figure 3.11



a b

Figure 3.12



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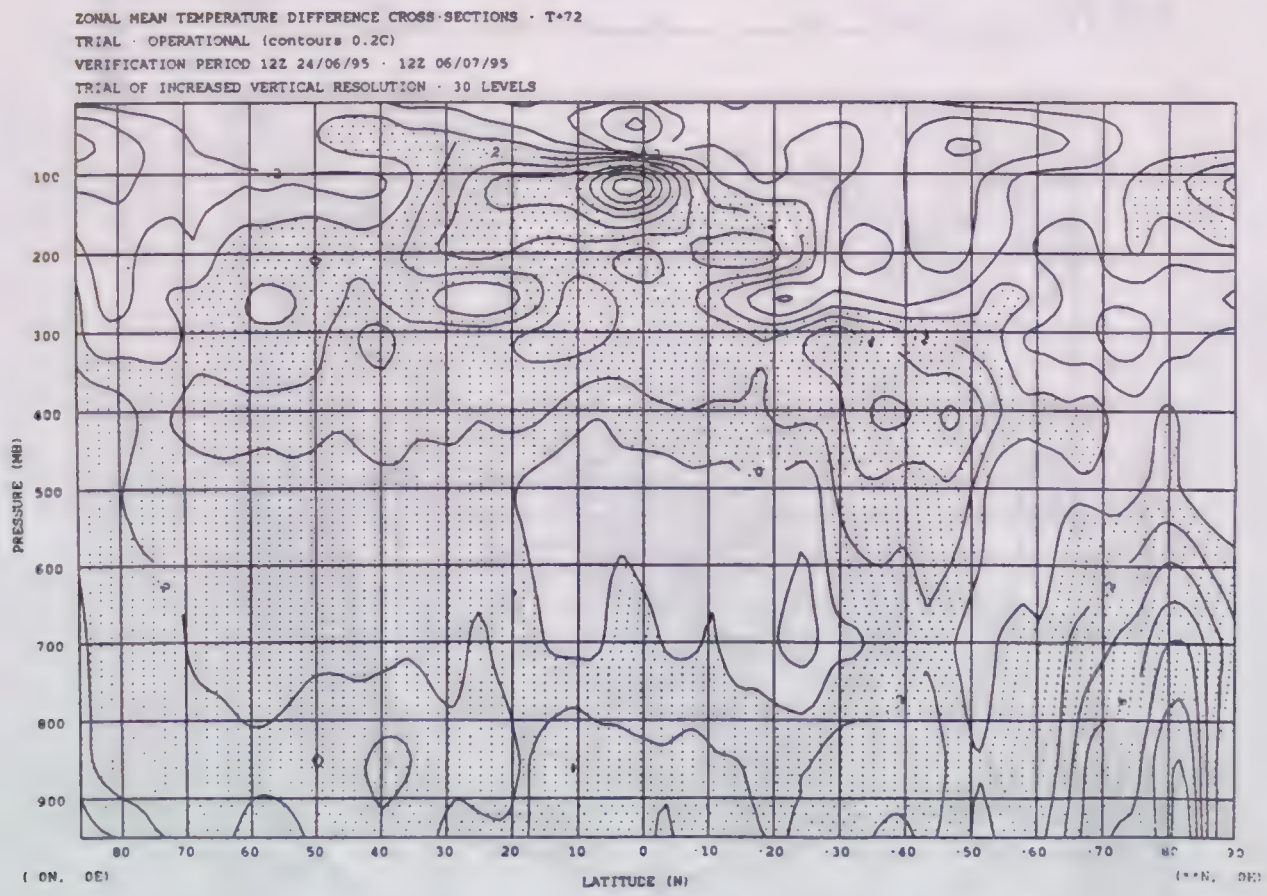
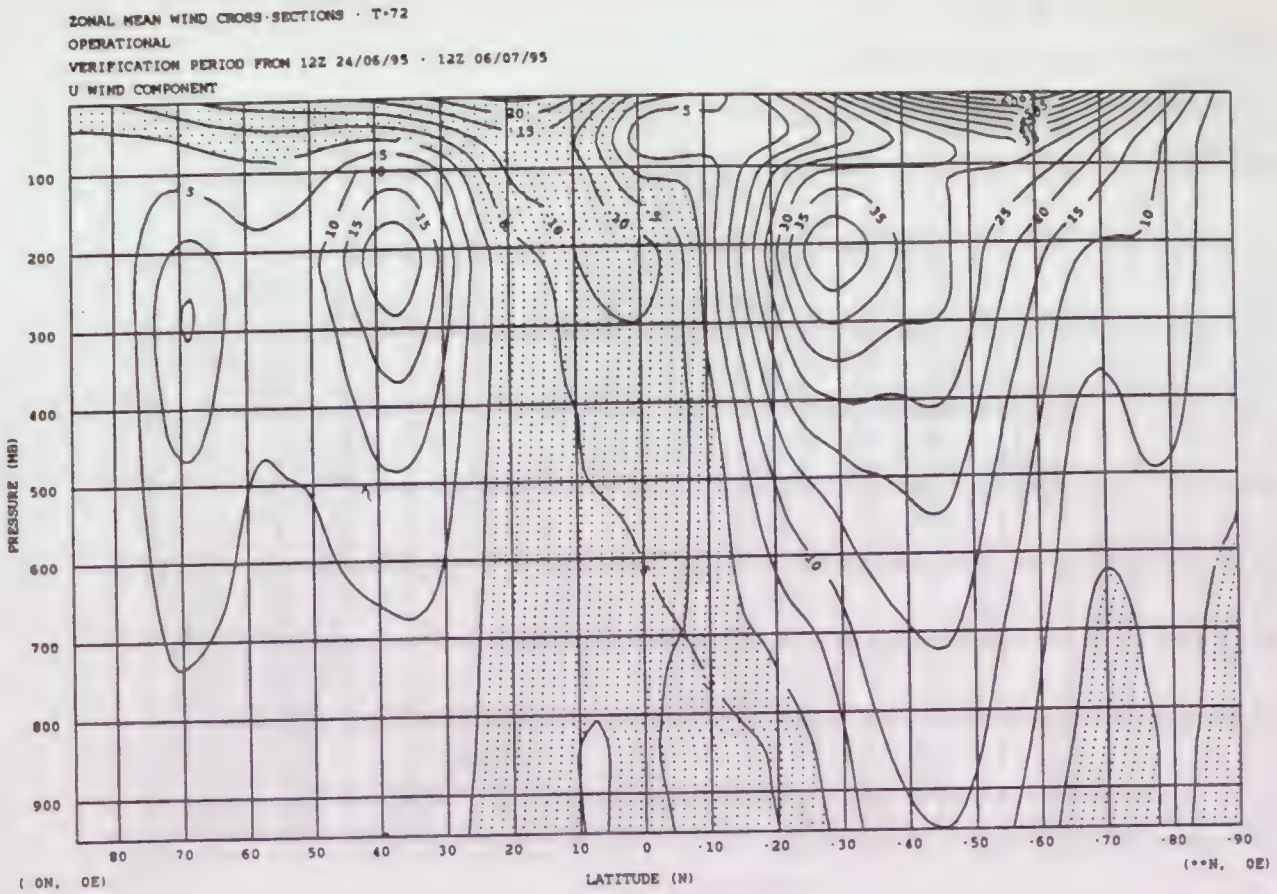


b

Figure 3.13 ·



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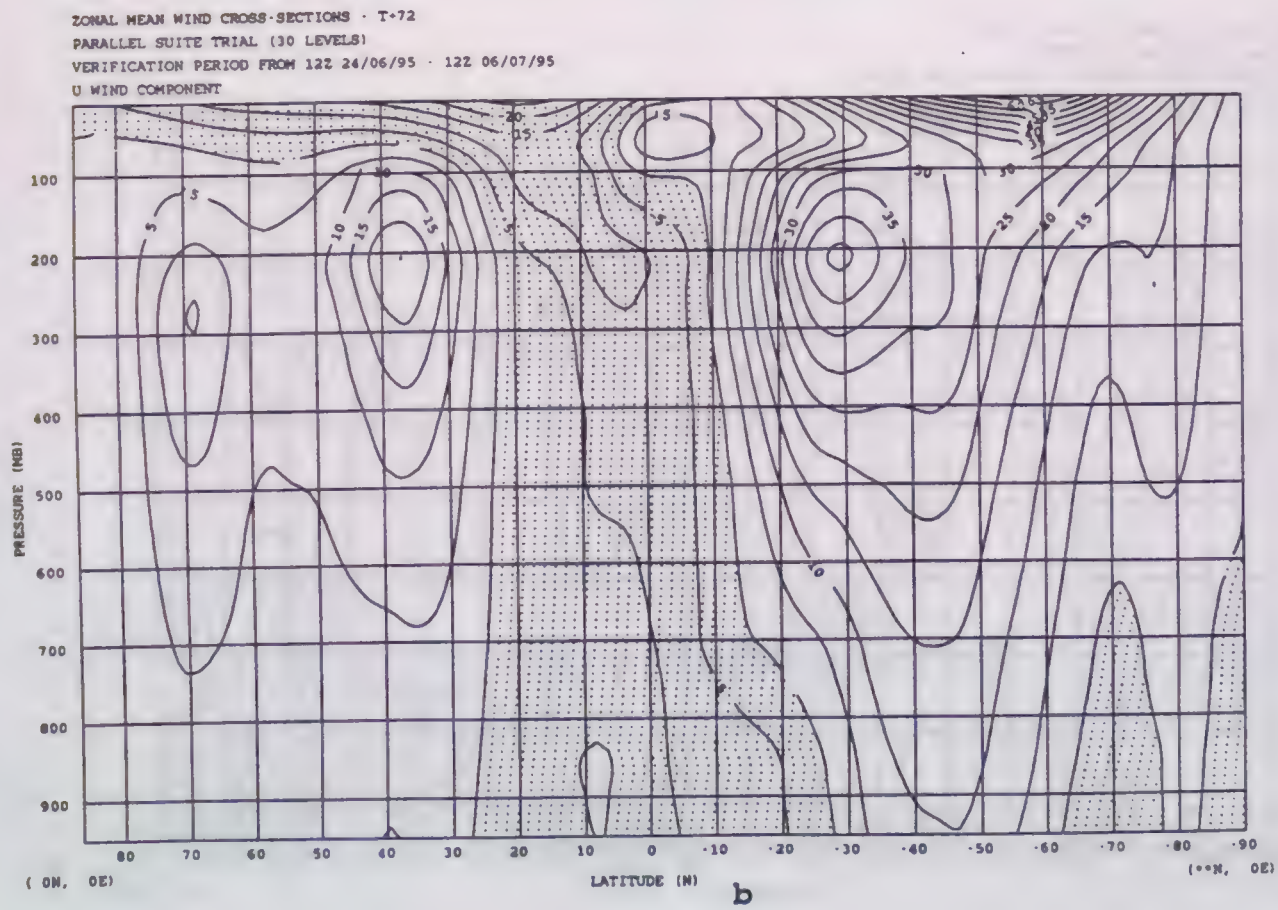

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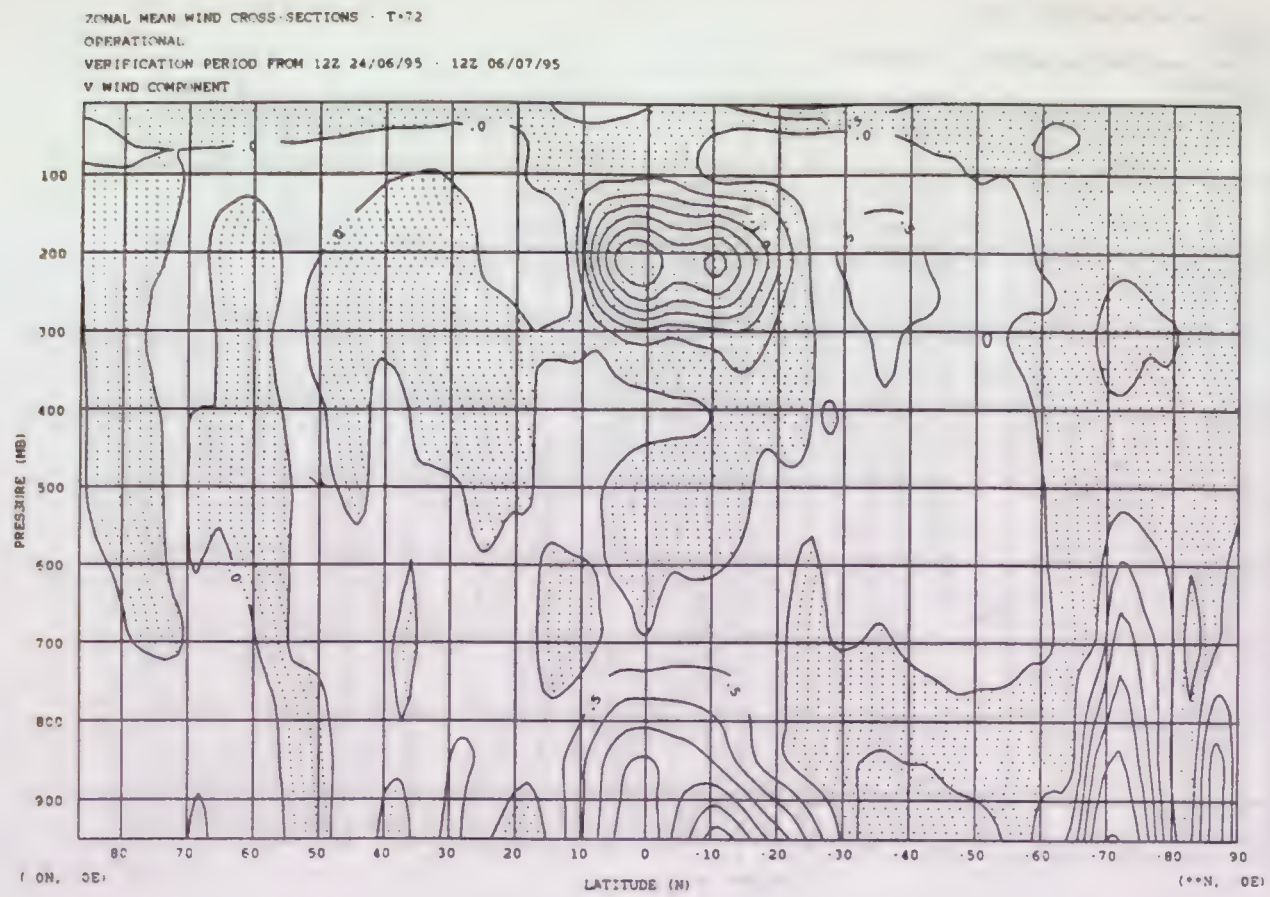
Figure 3.14



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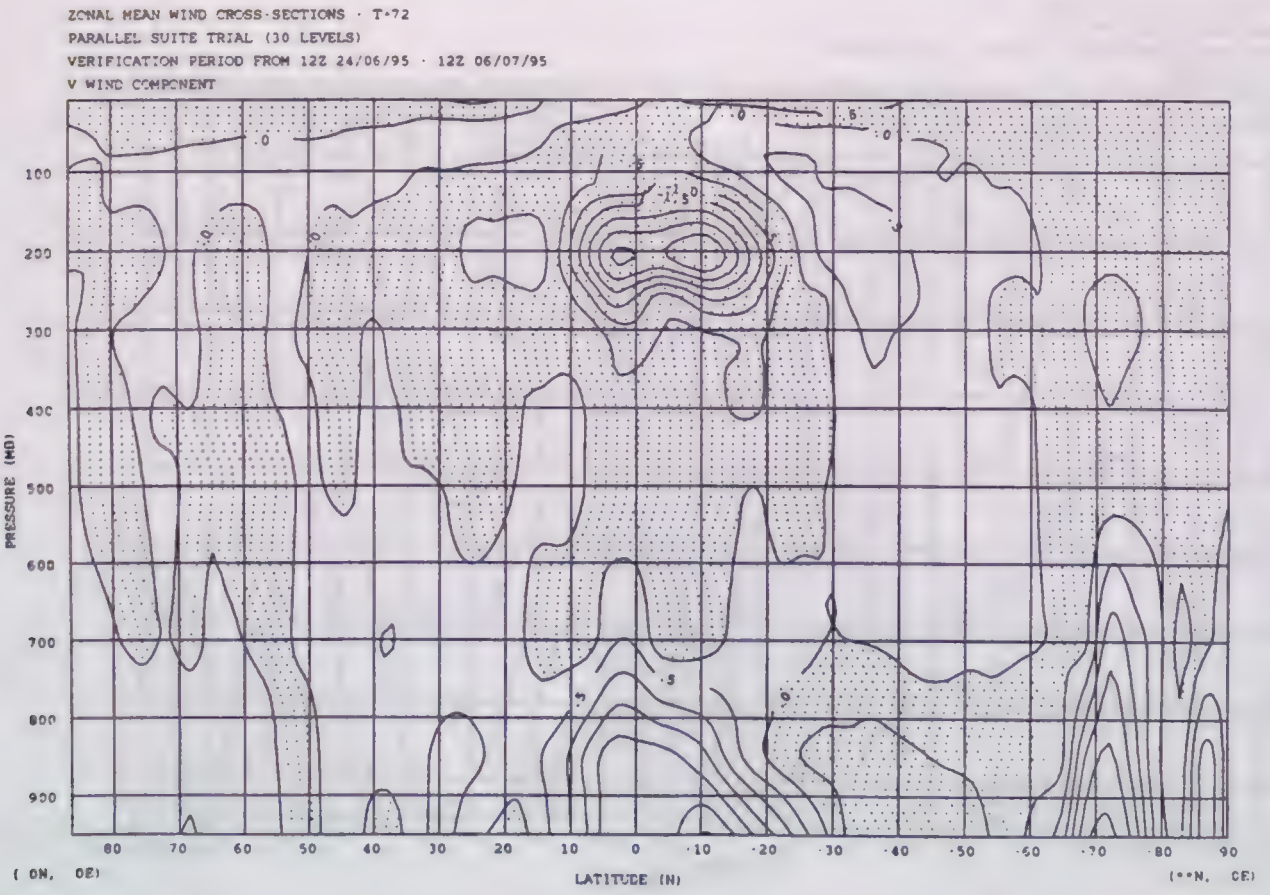
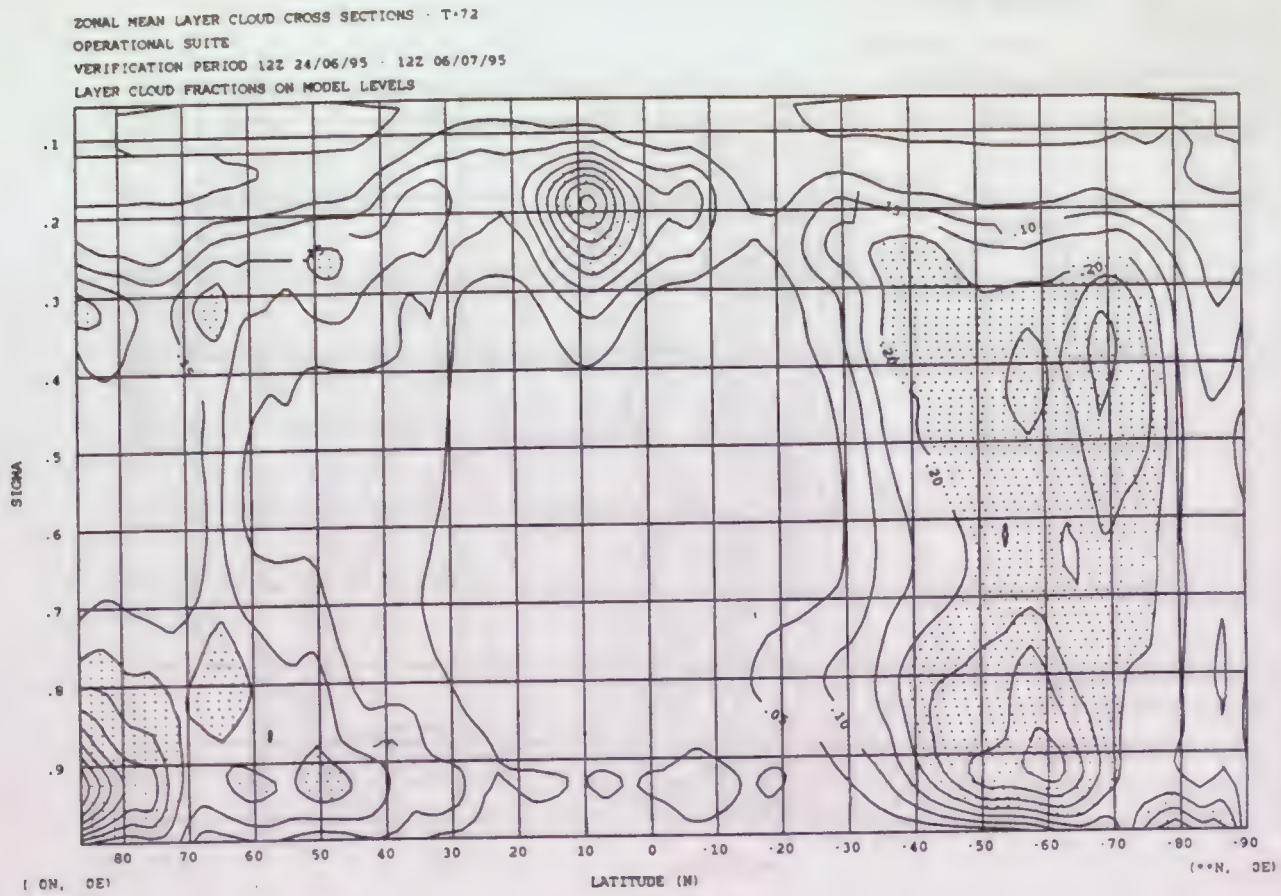
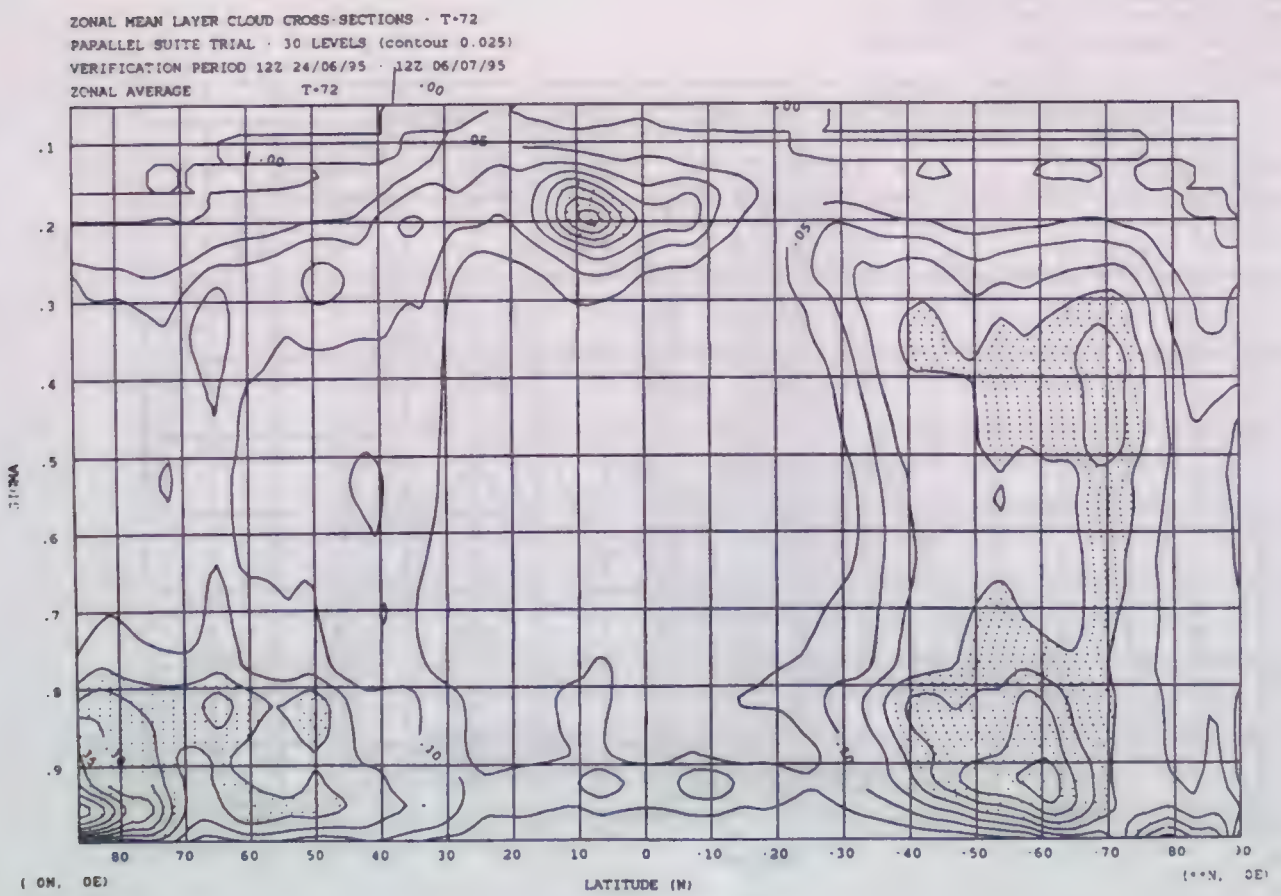


b

Figure 3.15

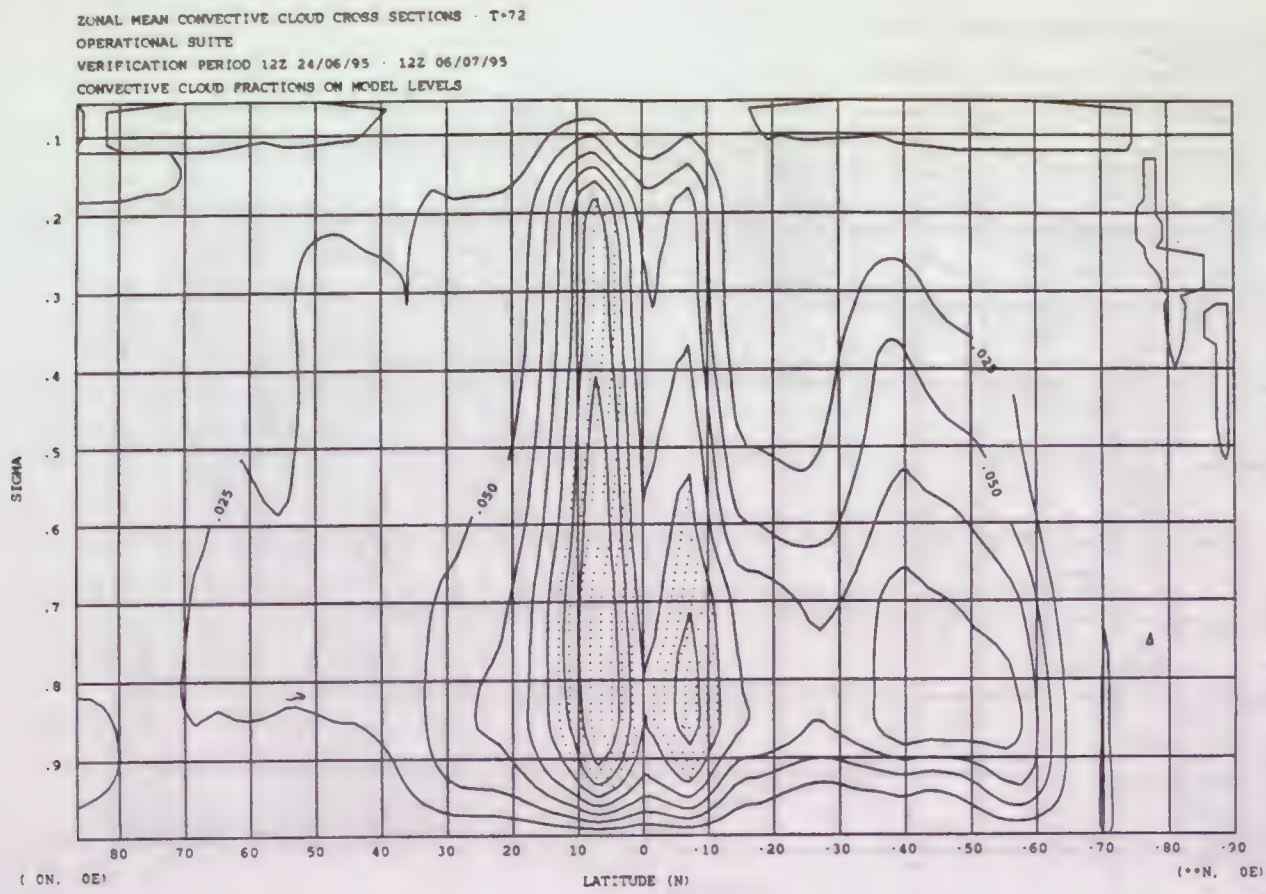


a

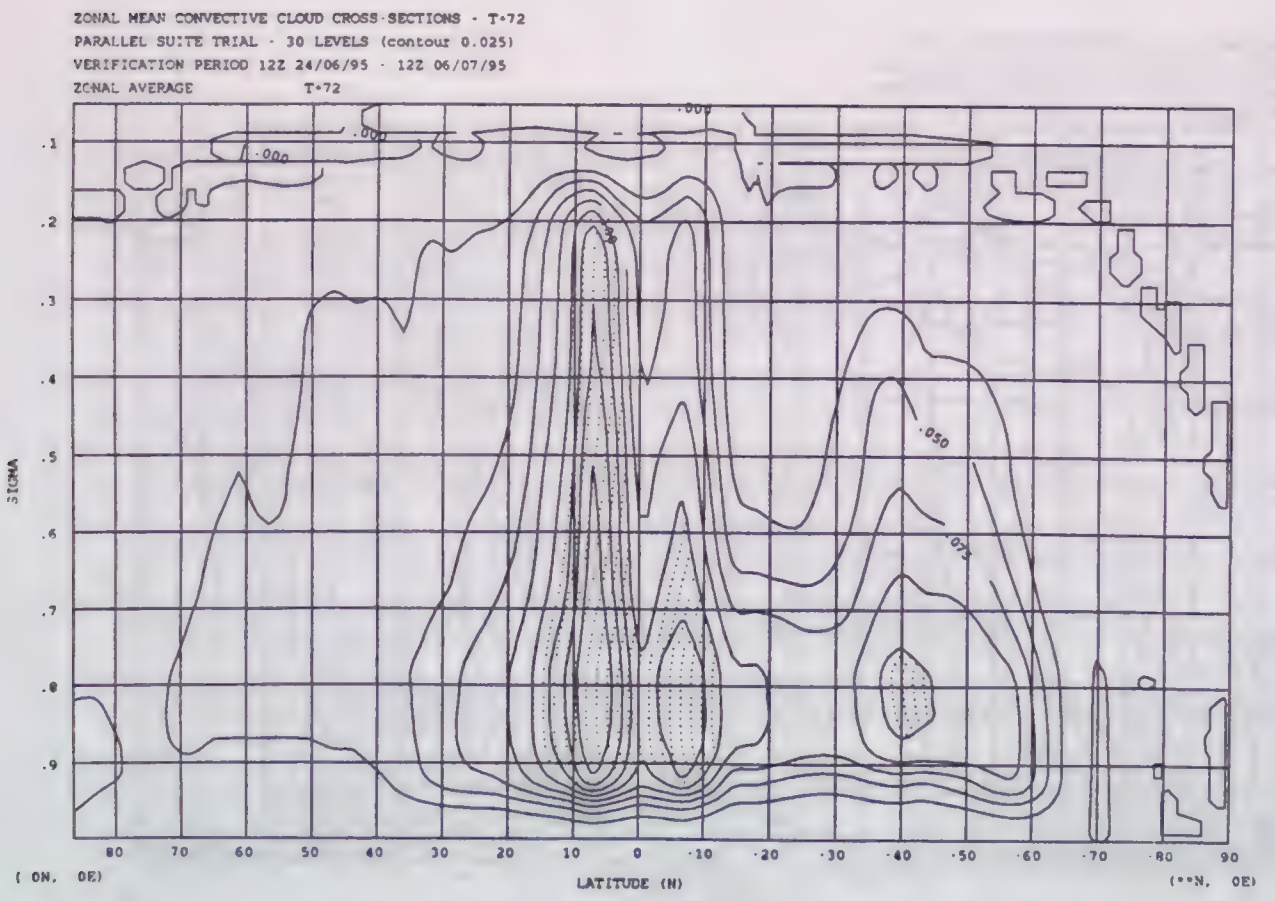


b

Figure 3.16



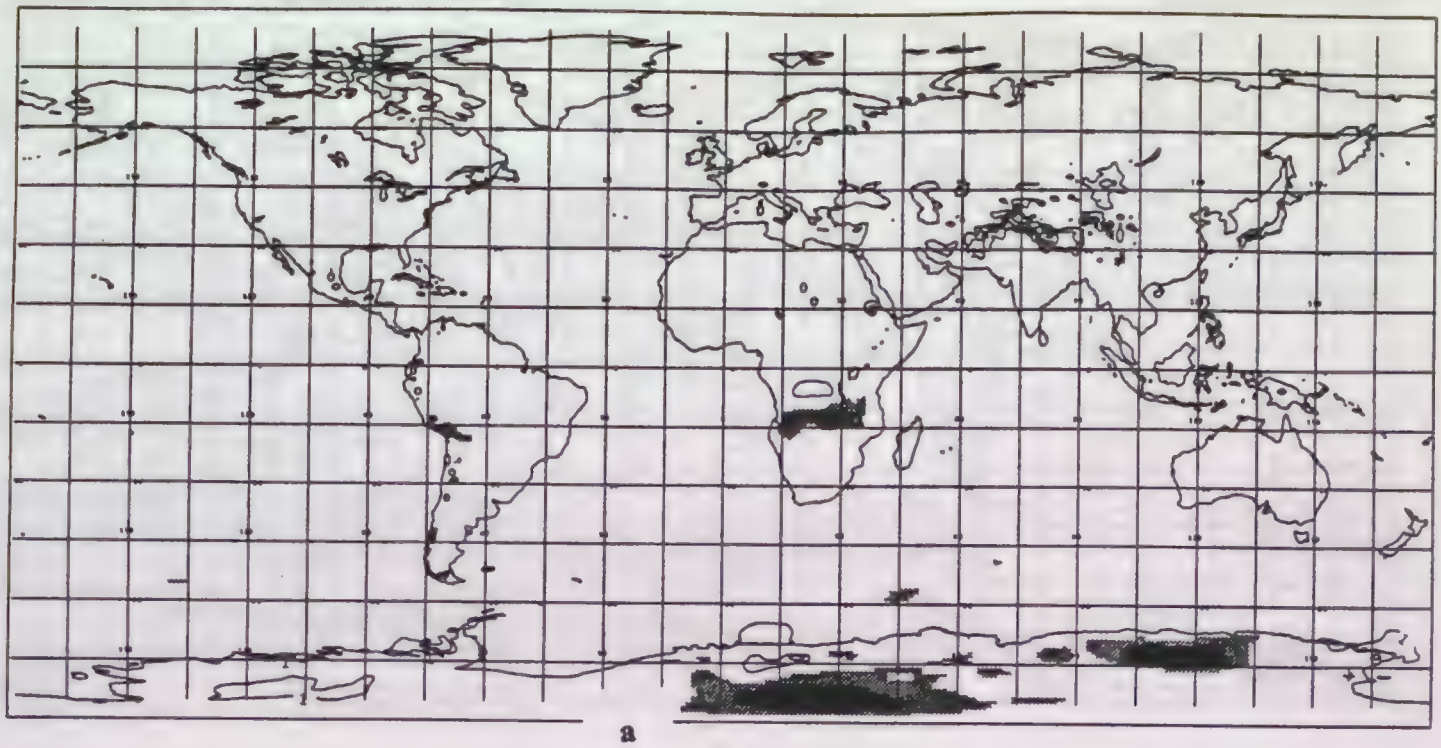
a



b

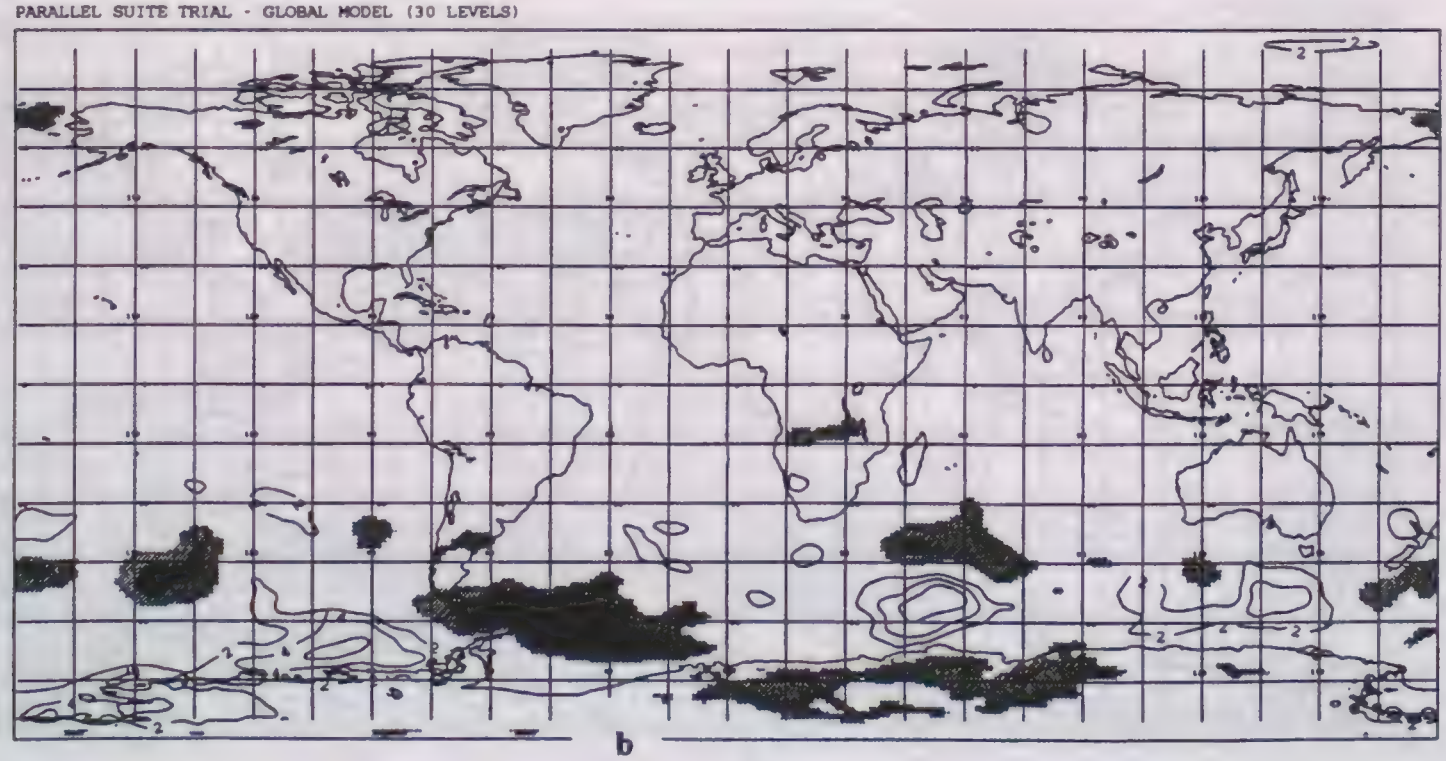
Figure 3.17

MEAN SEA LEVEL PRESSURE DIFFERENCES IN ANALYSES
TRIAL - OPERATIONAL
ANALYSES MEANED FROM 12Z 21/06/95 TO 12Z 03/07/95
PARALLEL SUITE TRIAL - GLOBAL MODEL (30 LEVELS)



a

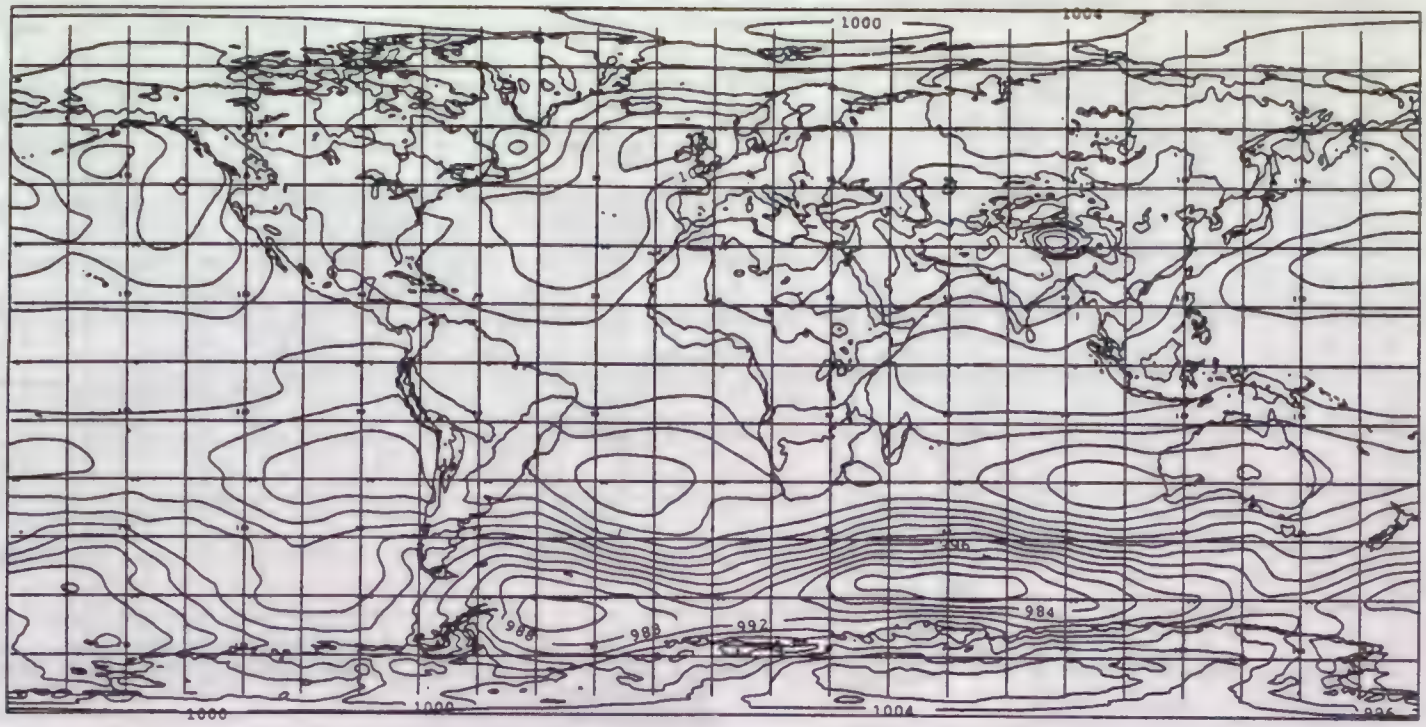
MEAN SEA LEVEL PRESSURE DIFFERENCES AT T+120
TRIAL - OPERATIONAL
FORECAST MEANED FROM 12Z 26/06/95 TO 12Z 08/07/95
PARALLEL SUITE TRIAL - GLOBAL MODEL (30 LEVELS)



b

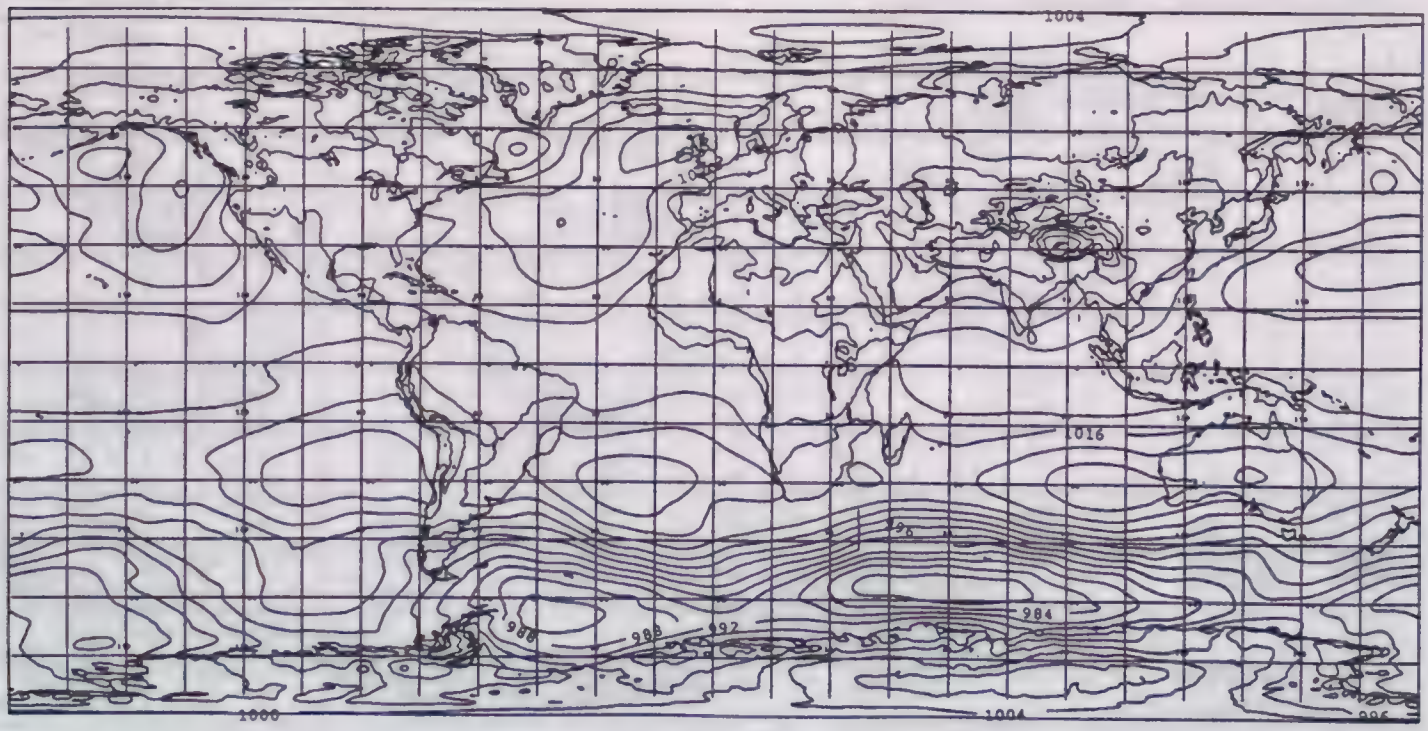
Figure 3.18.

MEAN SEA LEVEL PRESSURE T+120 FORECAST
OPERATIONAL
FORECAST MEANED FROM 12Z 26/06/95 TO 12Z 08/07/95
OPERATIONAL SUITE



a

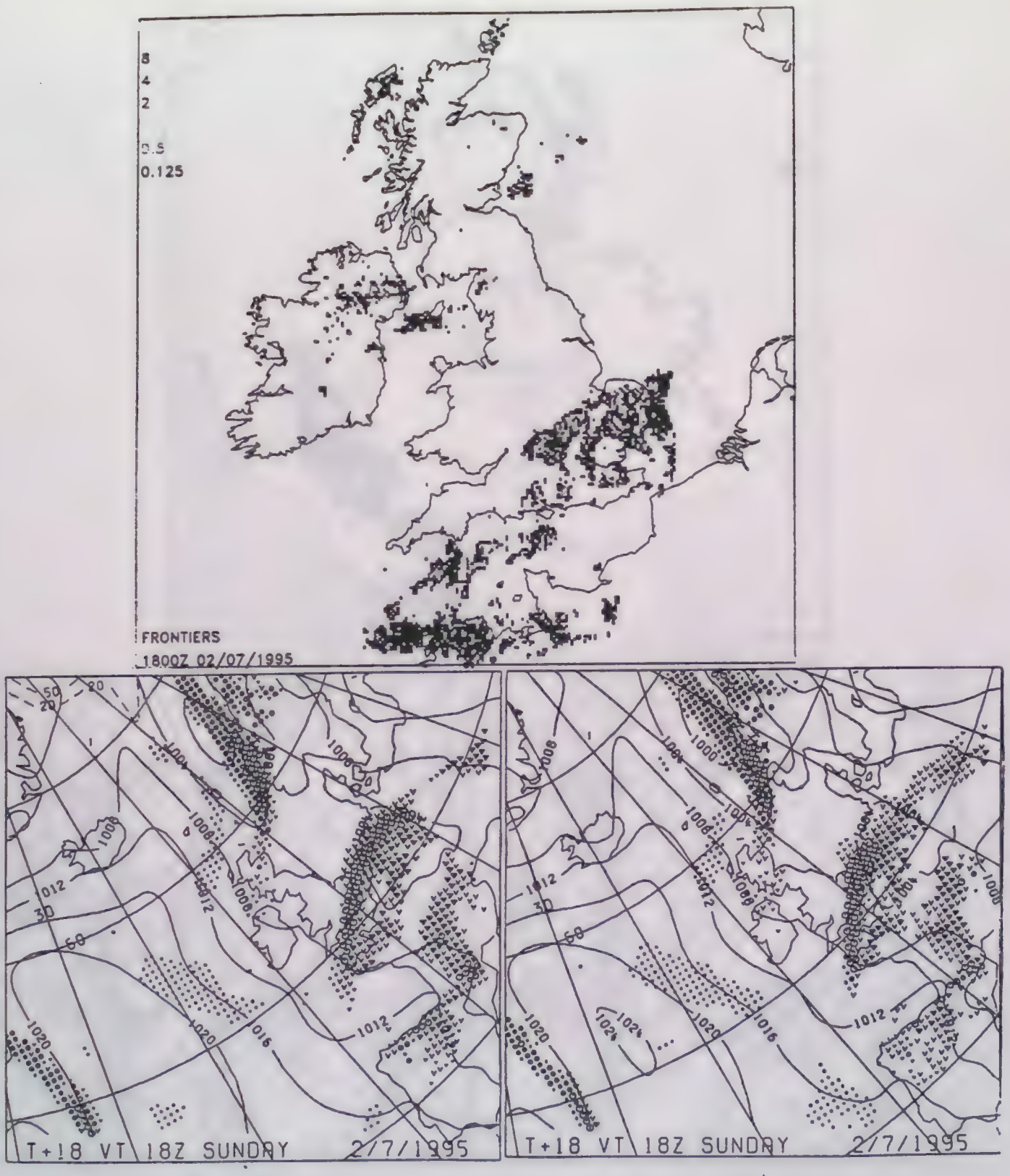
MEAN SEA LEVEL PRESSURE T+120 FORECAST
TRIAL (30 LEVELS)
FORECAST MEANED FROM 12Z 26/06/95 TO 12Z 08/07/95
PARALLEL SUITE TRIAL - GLOBAL MODEL (30 LEVELS)



b

Figure 3.19.

a

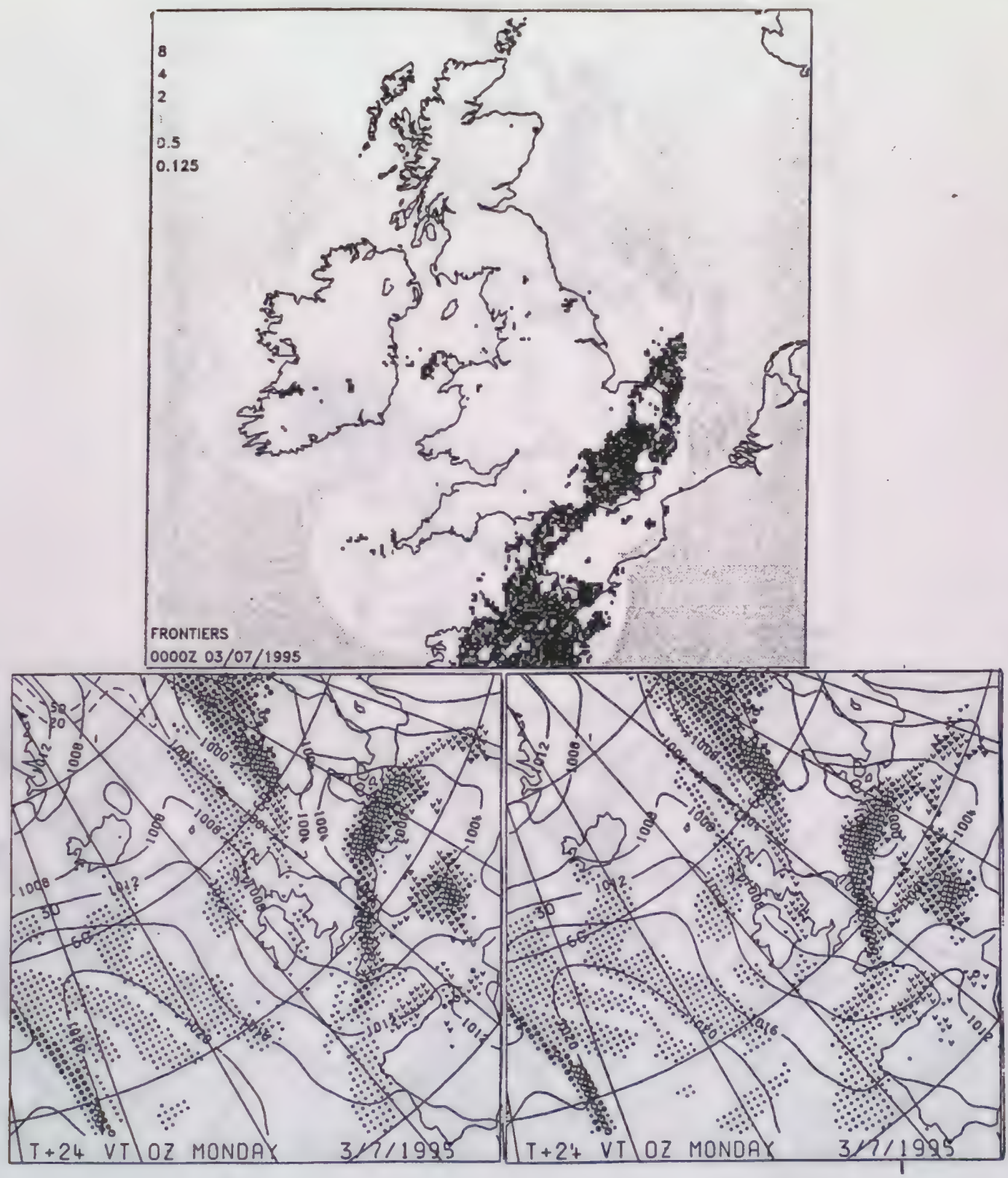


b c

FIGURE 4.1.

(a) Radar image for 18Z 02/07/95
T+18 forecasts of mean sea level pressure and total precipitation rate
(b) Operational forecast
(c) Trial (30 Levels) forecast

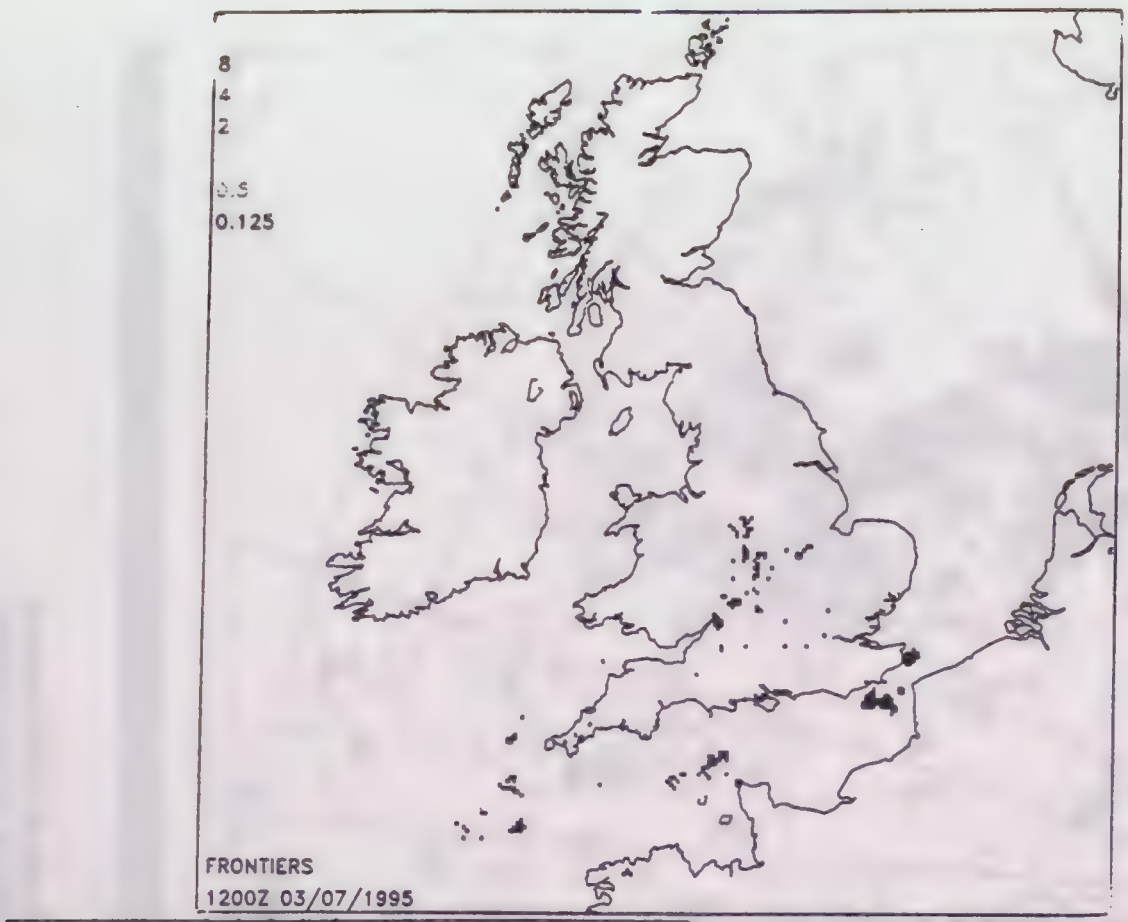
a

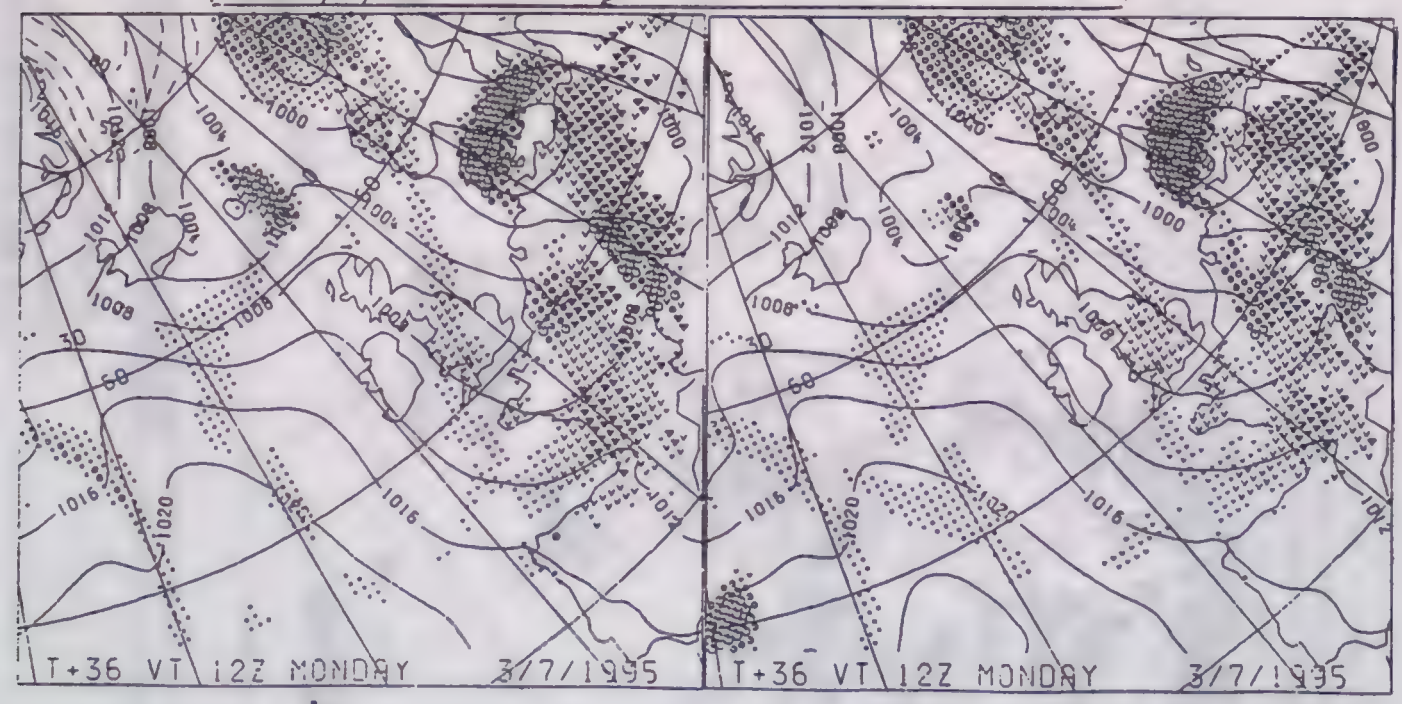


b c

FIGURE 4.2.
(a) Radar image for 00Z 03/07/95
T+24 forecast of mean sea level pressure and total precipitation rate
(b) Operational forecast
(c) Trial (30 Levels) forecast

a





b c

FIGURE 4.3.

(a) Radar image for 12Z 03/07/95
T+36 forecast of mean sea level pressure and total precipitation rate
(b) Operational forecast
(c) Trial (30 Levels) forecast

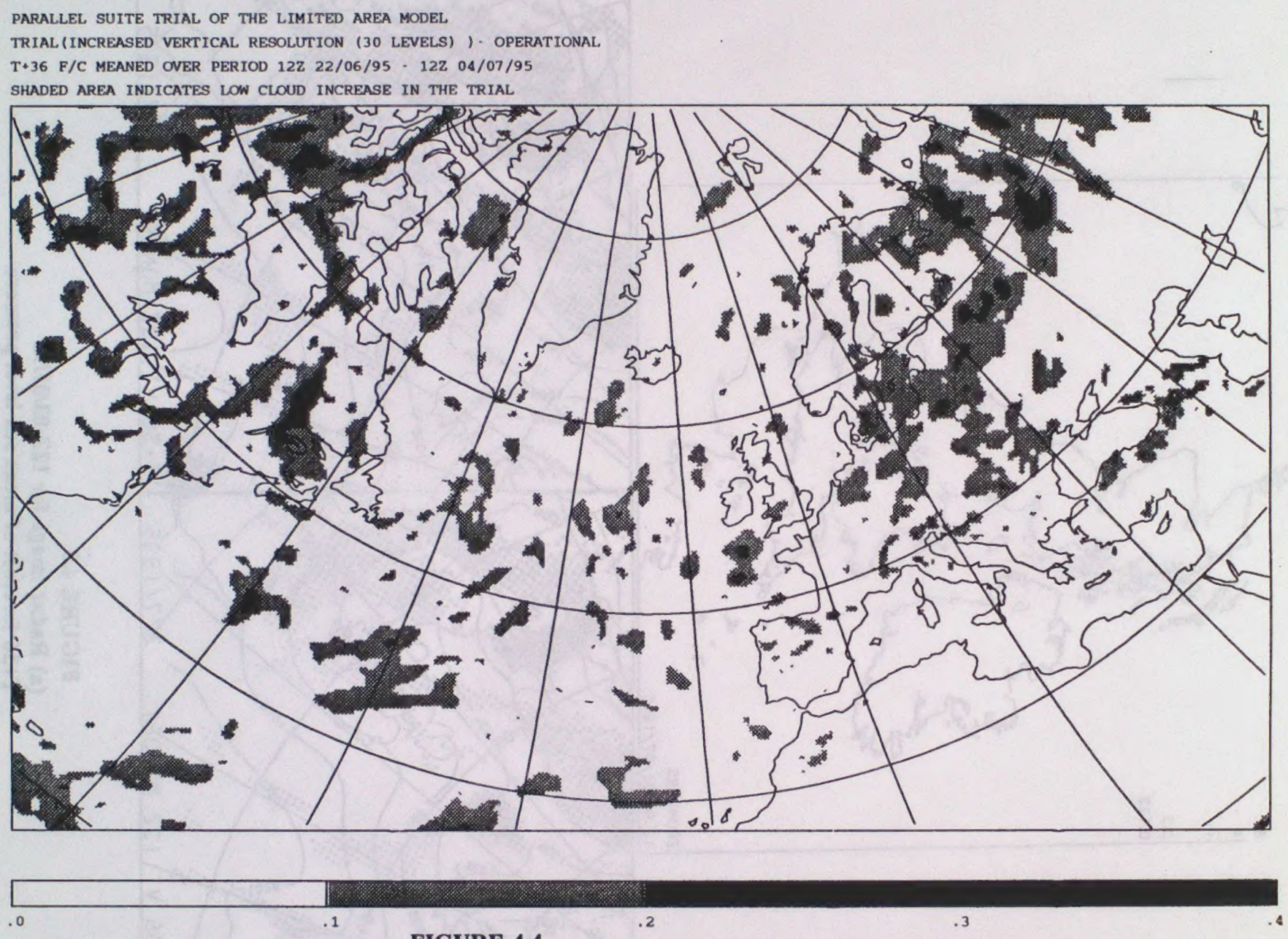


FIGURE 4.4.

Mean low cloud differences at T+36, meaned over the period 12Z 22/06/95 to 12Z 04/07/95. Shaded area shows increased low cloud in the fo[illegible]hts.

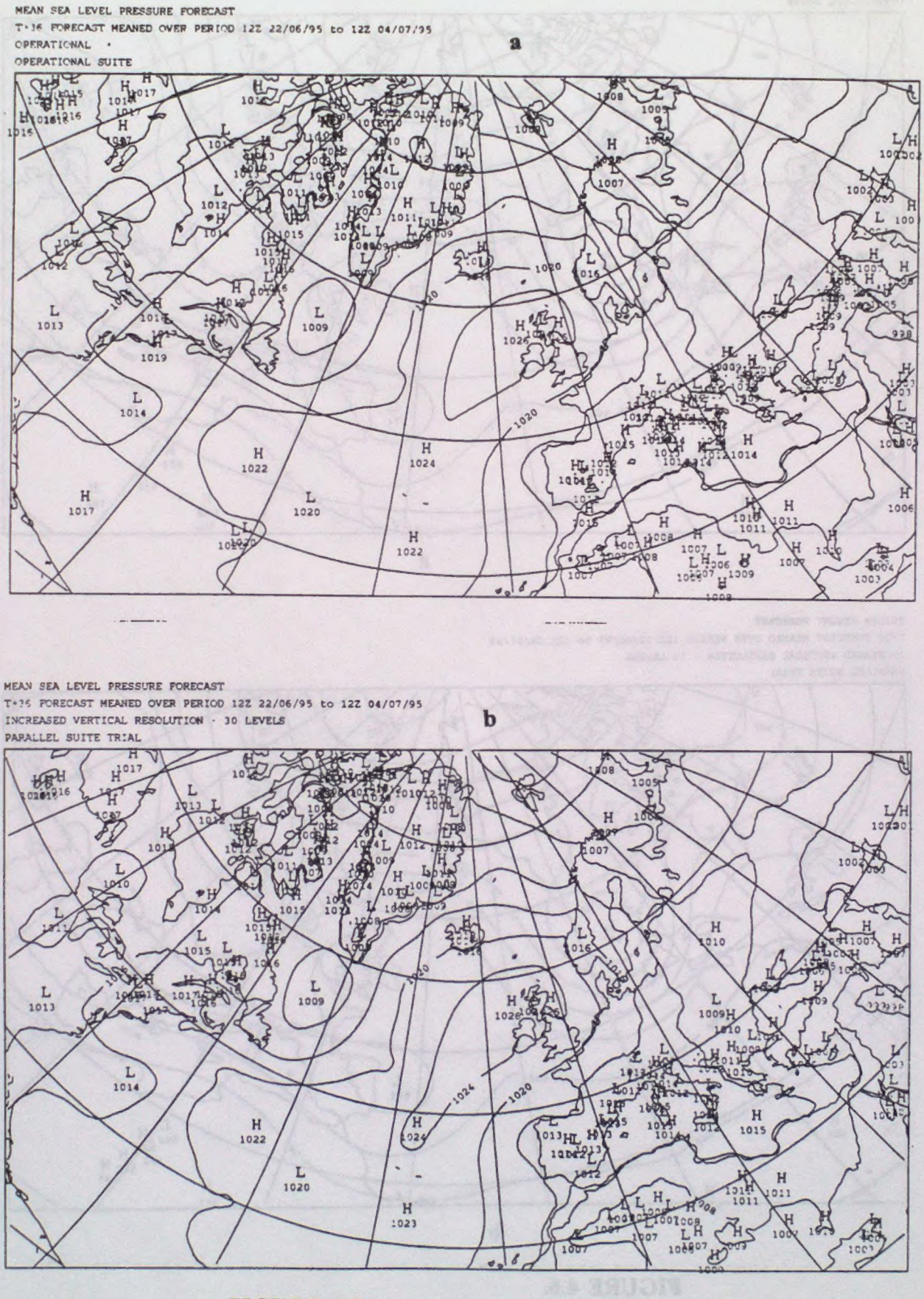
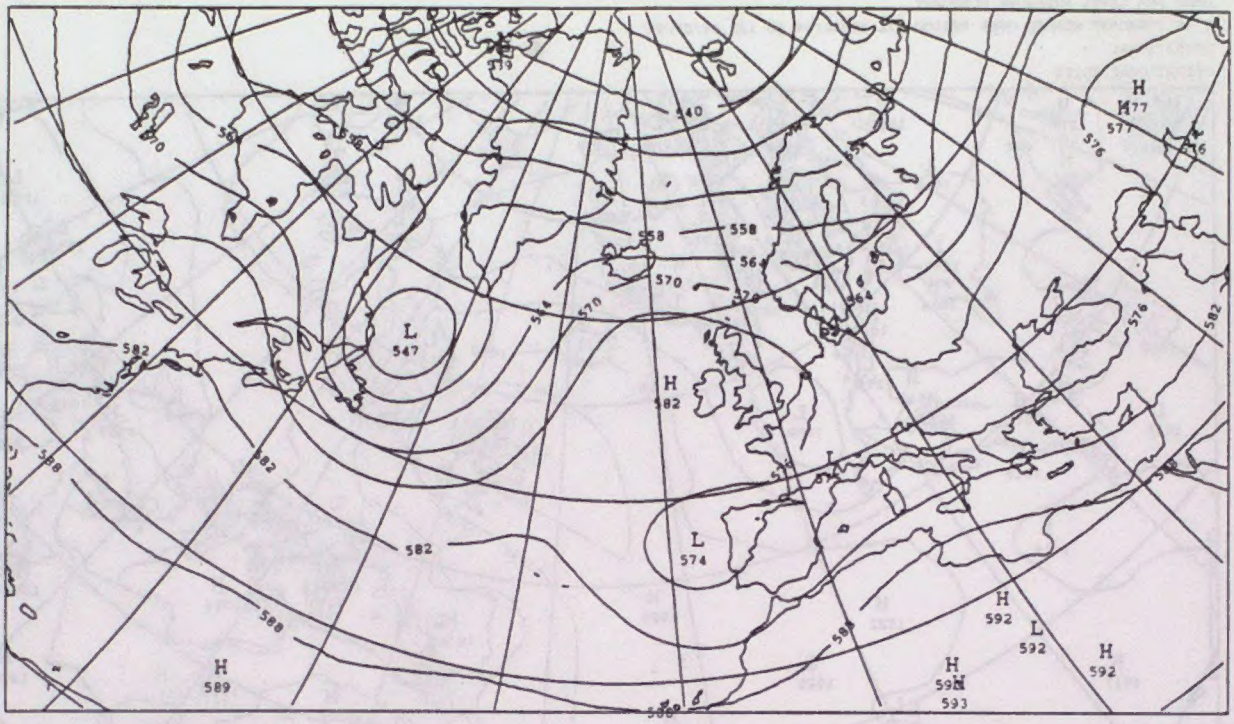


FIGURE 4.5.

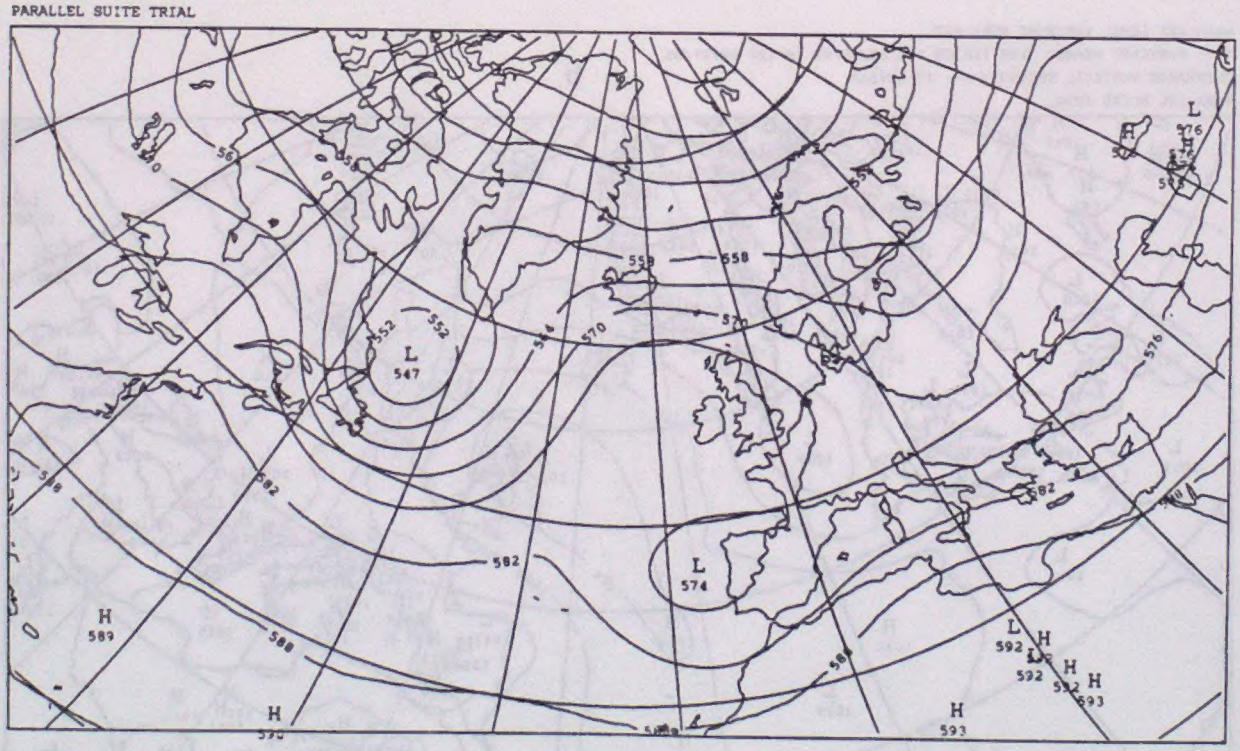
T+36 mean sea level pressure forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational
(b) Trial (30 Levels)

500hPa HEIGHT FORECAST
T+36 FORECAST MEANED OVER PERIOD 12Z 22/06/95 to 12Z 04/07/95
OPERATIONAL
OPERATIONAL SUITE



a

500hPa HEIGHT FORECAST
T+36 FORECAST MEANED OVER PERIOD 12Z 22/06/95 to 12Z 04/07/95
INCREASED VERTICAL RESOLUTION - 30 LEVELS
PARALLEL SUITE TRIAL

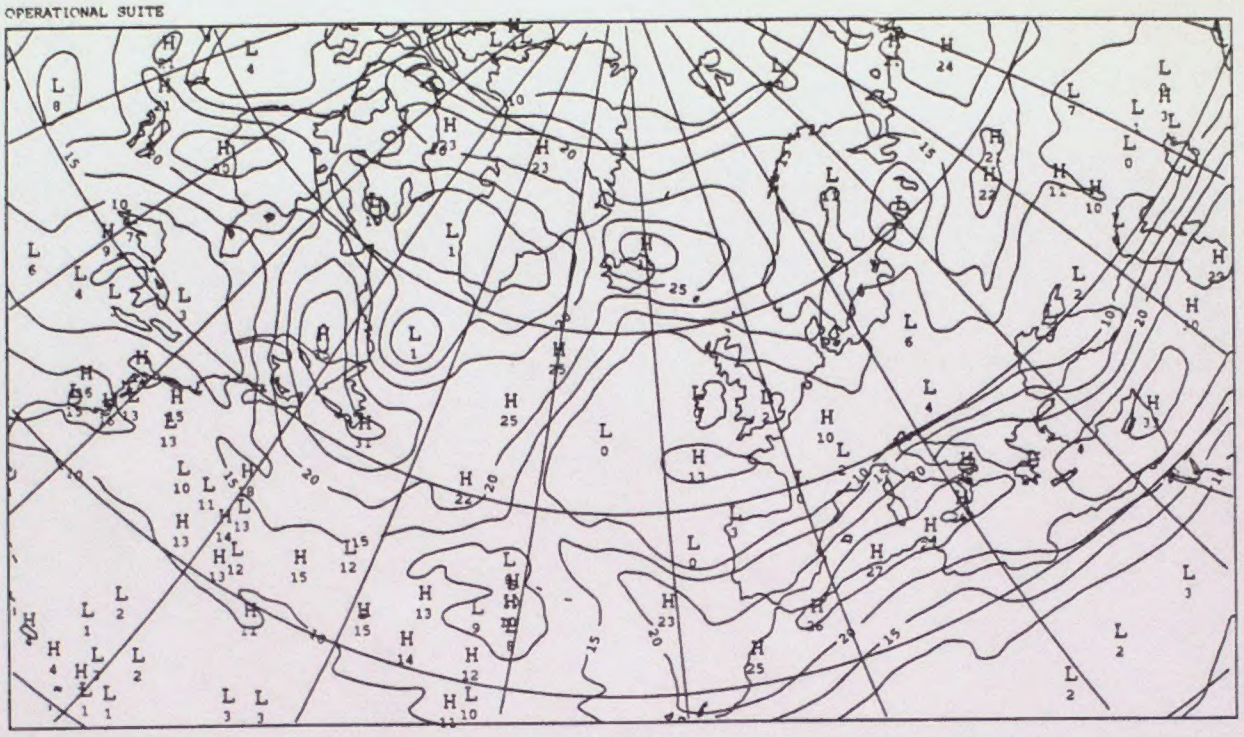


b

FIGURE 4.6.

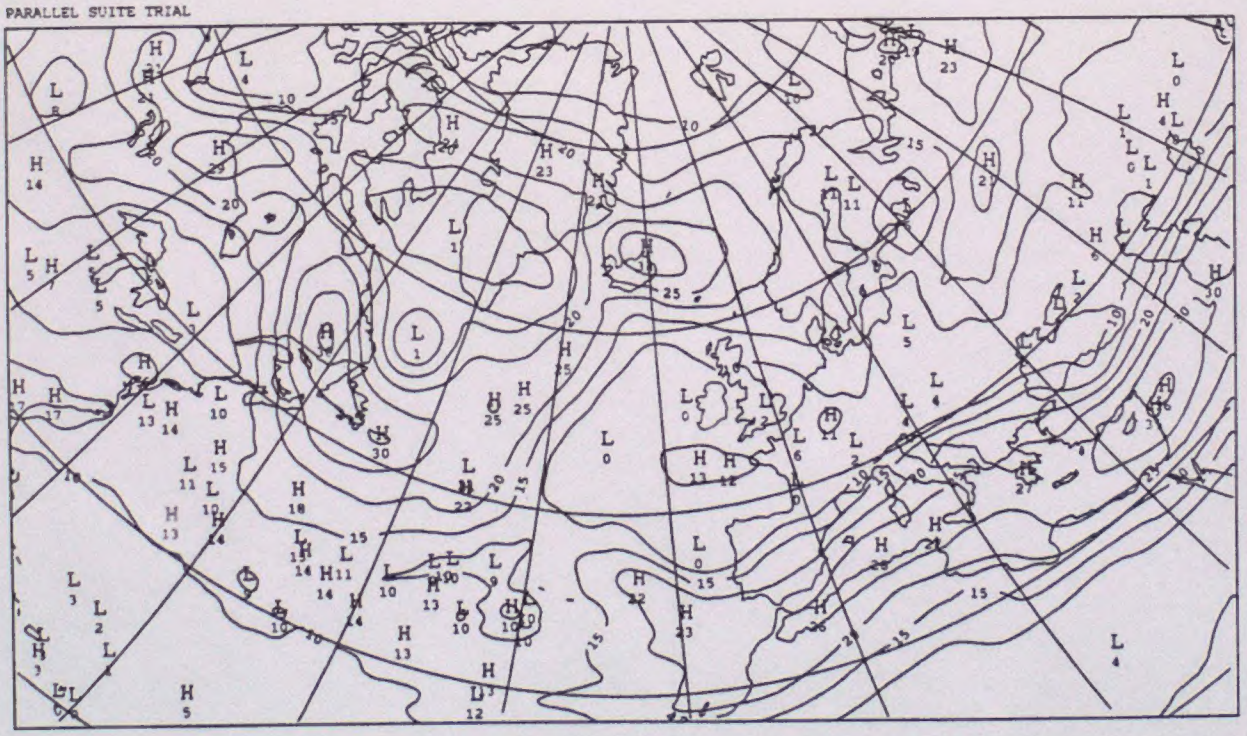
T+36 500hPa height forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational
(b) Trial (30 Levels)

250MB MEAN WIND
T+36 F/C MEANED OVER PERIOD 12Z 22/06/95 - 12Z 04/07/95
OPERATIONAL
OPERATIONAL SUITE



a

250MB MEAN WIND
T+36 F/C MEANED OVER PERIOD 12Z 22/06/95 - 12Z 04/07/95
TRIAL(30 LEVELS)
PARALLEL SUITE TRIAL



b

FIGURE 4.7.

T+36 250hPa wind forecasts meaned over the period 12Z 22/06/95 to 12Z 04/07/95
(a) Operational
(b) Trial (30 Levels)